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On the 17th of July, 1912, death took M. Henri Poincaré at the zenith of his intellectual powers. The loss of this original, brilliant and profound spirit fell heavily upon the whole intelligent world. I was talking with Professor Puiseux at the Paris Observatory when word came that a blood clot had stopped Poincaré's heart, and I witnessed the bewilderment and the consternation with which the news of his unexpected death was received by his colleagues. That they should have been shocked when their most brilliant light was extinguished was only natural; but it was indeed a surprise to me that the name of Poincaré, the mathematician, should have been so well known to the great mass of Frenchmen, that his genius was something of which they should have been so proud, and that his death should have been so universally and so sincerely mourned. These things bear witness to their intelligence and discernment, as well as to the greatness of his reputation.

Poincaré was born at Nancy on the borders of Lorraine, April 29, 1854. He was the son of an eminent physician and the cousin of M. Raymond Poincaré, Premier of France. He was educated at the *Lycée de Nancy*, *l'École Polytechnique* and *l'École Nationale Supérieure des Mines*, and received his doctor's degree from the University of Paris in 1879 at the age of twenty five. Although it was only thirty-three years from the time he wrote his doctor's dissertation until his death, yet his activity was so prodigious that, according to the funeral oration by M. Lippmann, *Prèsident de l'Académie des Sciences*, he had published in addition to his numerous books more than 1500 memoirs. Think of an average of nearly one paper a week for many years, even though some of them may have been minor notes! In spite of the fact that Poincaré died at fifty-eight, probably not even Euler nor Cauchy equaled him in the

quantity of his scientific productions, and a large part of what he wrote compares favorably in quality with the best that any man has produced. Painlevé said that there was not one of his 1500 works which did not contain something masterly, which did not carry the mark of a lion.

The honors bestowed upon Poincaré were commensurate with his achievements. At the age of twenty-seven he was given the Chair of Mechanics, at Paris, by the Faculty of Sciences. He also occupied successively the chairs of Mathematical Physics, of Mathematical Astronomy, and of Celestial Mechanics. At thirty-two he was elected to *l'Académie des Sciences*, and in 1909 he was received into *l'Académie Française*. He was made a Foreign associate of the (U.S.) National Academy of Sciences, and he was similarly honored by almost every other scientific society of the whole world. He received the prize offered by king Oscar II, of Sweden, for work on the problem of three bodies, the gold medal of the Royal Astronomical Society of London, the Sylvester medal of the Royal Society of London, the Bolyai prize of the Hungarian Academy of Sciences, the Lobatchefsky gold medal of the Kasan Mathematical Physics Society, two prizes from the Paris Academy, and a gold medal from the French Association for the Advancement of Science. Honorary degrees were bestowed upon him by the universities of Cambridge, Oxford, Glasgow, Brussels, Christiana, and Stockholm. For fifteen years he was, by common consent, given first place in every gathering of scientific men which he attended.

Poincaré was much preoccupied with his meditations, and there are several well-known stories of his absentmindedness. But he is described by his colleagues as having been singularly conscientious in the performance of his university duties, never asking any favors, giving freely of his ideas for doctors' theses, and even carefully correcting the dissertations of the candidates for the baccalaureate. His official duties were very heavy, and in view of the fact that he was the leading spirit in every group of men to which he belonged our amazement at the extent and profundity of his researches increases. He was a member of the *Bureau des Longitudes*, president of the *Conseil des l'Observatoires*, member of the *Conseil de l'Observatoire de Paris*, president of the *Societé Astronomique de France*, president of the editorial committee of the *Bulletin Astronomique*, and he was appointed to almost every committee of national character whether of mathematics, astronomy, astrophysics, physics or philology.

In personal appearance there was nothing in Poincaré which would indicate the great genius. He had neither the delicately refined and scholarly face shown in the portraits of Lagrange, nor the severe and imperious mien of Newton and Gauss. He was a little below medium height and, though not muscular, was well developed physically. He was rather stooped, at least since 1904, when I first saw him. He used spectacles, wore a full beard, and was not fastidious in dress. In repose he would not be likely to attract attention, but when he spoke his eyes lighted up with a wonderful intelligence and his voice was full and smooth.

While from the product of Poincaré's brain we can not but regard him as a ceaselessly running machine which had unlimited powers of imagination, a penetrating intuition, and an unerring logic, yet there was a human side to him, a side fully known only to his close friends and especially to his family. In insisting on this phase of Poincaré's character I can, of course, reflect only what I have learned from those who were in a position to know. The evidence is clear that he was simple and unaffected, kindly disposed to all, companionable, and fond of his family and of his friends. As boys he and Appell wandered together over the hills of Nancy after their classes, and the bonds of friendship begun there grew stronger with the years. What glory these two and that other great son of Lorraine, Hermite, have shed on France! And the home life of Poincaré is said to have been ideal. Mme. Poincaré is a lady of intelligence who appreciated the genius of her husband, and who shielded him from the distractions and annoyances which would have interfered with his meditations. Now she, a son, and three daughters are desolate and weighed down with grief for him whom they have lost, and it is doubtless small consolation to them that he was one of the greatest geniuses the human race has produced, and that the whole scientific world joins them in their sorrow.

It has been mentioned that Poincaré occupied successively a number of different chairs at Paris. Each year he lectured on a different subject; and while in general these lectures were largely expositions of the ideas of others, his grasp of essentials, whether mathematical or physical, was so sure, and his manipulation of the machinery of analysis was so extraordinarily skillful, that the topics he discussed were revealed in a new light which often disclosed properties and relations they were not known to possess. An association of those who had been

his students was formed for the purpose of reporting and publishing his lectures. It is to this association that we owe sixteen volumes of the lectures of Poincaré. While they form a remarkable contribution to science for one man, they have some of the faults to be expected from the method of their production,—the faults which are incident to a stenographic report of a subject as it was developed day by day without being worked over and rewritten after repeated reflection, those of incompleteness, and those due to printing without the supervising care of the author. This is not to be taken as any reflection on the editors of these valuable works, but means only that the lectures suffer by comparison with the more finished memoirs.

For present purposes the work of Poincaré may be divided into three parts, that which is on pure mathematics, that which is on the applications of mathematics, and that which is on philosophical questions. I shall not attempt, and I am not qualified, adequately to discuss any one of these three parts, much less all three. Their extent and profundity can be inferred from the fact that there is not a man living who is fully competent even to appraise all this work. Therefore how high we must rate the genius of him who created it!

Poincaré wrote on nearly every branch of pure mathematics. The importance of his papers can be inferred from the enormous number of references to his theorems in all modern treatises, especially on the various branches of analysis. The emphasis on analysis does not mean that he neglected geometry, analysis situs, groups, number theory, or the foundations of mathematics, for he illuminated all these subjects and others; but it is placed there because this domain includes his researchess on differential equations, dating from his doctor's dissertation to very recent times, his contributions to the theory of functions, and his discovery of fuchsian and thetafuchsian functions. His command of the powerful methods of modern analysis was positively dazzling.

In the application of mathematics Poincaré covered the whole field of celestial mechanics and mathematical physics. Beyond question his celebrated researches on the problem of three bodies, which won the prize offered by king Oscar II, and which were developed more fully in three volumes of his *Les Méthodes Nouvelles de la Mécanique Céleste*, are his most important contributions to the applications of mathematics. Here again there is danger that selecting the one thing for

special remarks will make us forget that he wrote an epoch-making memoir on the figures of equilibrium of rotating masses of fluid, that he wrote profoundly on the tides, connecting the subject with the recent theory of integral equations, on light, on elasticity, and on the whole realm of mathematical physics.

It has been remarked a number of times recently that the original memoir of Poincaré on the problem of three bodies, for which the prize of King Oscar II was awarded, contained an error, and that the published paper differed from the one originally submitted. Unfortunately and erroneously the impression has been left in some of these statements that the first investigation was quite wrong and of little value. The original memoir did contain an error which was discovered by Phragmèn, of Stockholm, but it affected only the discussion of the existence of the asymptotic solutions; and in correcting this part Poincaré made no attempt to conceal the facts, and confessed fully his obligations to Phragmèn. While the error was unfortunate, there is not the slightest doubt that in spite of it, and even if it had been known at the time, the prize was correctly bestowed. If all the parts affected by the error are omitted, the memoir still remains one whose equal in originality, in results secured, and in extent of valuable field opened, it is difficult to find elsewhere. There are but very few men, even of high reputation, who have produced more in their whole lives that was really new and valuable than that which was correct in the original investigation submitted by Poincaré.

Those who have not devoted themselves to the mathematical side of astronomy will probably hope as they read the preceding paragraph that I am about to explain to them the real nature of this wonderful work of Poincaré. I should like to gratify their desires in this direction, but the fact that it cost me a great deal of labor to understand it, and the difficulties I have in getting the ideas understood by our students, even in the simpler and special cases in which they are introduced, deter me from making the attempt. Any one can see how hard it would be to explain to a man who had never studied calculus or trigonometry or algebra the mathematical methods by means of which the area of the surface of an ellipsoid is computed. It is equally hard to explain the methods used by Poincaré to one who may have had the calculus, but who has not studied the canonical equations of dynamics, functions of a complex variable, implicit functions, and the theory of differential equations as based on these subjects. Consequently I

shall not attempt it, but, having enumerated some of the prerequisites to the reading of *Les Méthodes Nouvelles*, I shall leave the discussion of the processes employed by Poincaré with the remark that in power and elegance they are as much beyond those of Laplace as his were beyond the geometry of Newton.

The original problem attacked by Poincaré was that of finding whether or not the solar system is stable. It was suggested by the great mathematician Weierstrass who, in the last years of his life, devoted considerable attention to it. The difficulty in obtaining an answer to the problem arises from the fact that the expressions which have been developed by mathematicians to represent the coördinates of the planets converge either not at all or for only a limited time. It is known by everyone that the planets move in nearly elliptical orbits. Their mutual interactions cause relatively small periodic oscillations, having a great number of short periods, from the purely conic section motion. There are also periodic oscillations of long periods. In addition to this, the longitudes of the nodes and of the perihelia continually increase or decrease. The real question is whether there may not be, in addition to the complex mixture of cyclical changes, a small residue of change in one direction of such a nature that the system will ultimately be wrecked. There is at present no rigorous answer to the question, but Poincaré showed that solutions exist in which the motion is purely periodic, and therefore that in them at least no disaster of collision or indefinite departure from the central mass will ever occur.

It is commonly stated that the number of periodic solutions of the problem of three bodies was proved by Poincaré to be infinite. Let us see in a special case precisely in what sense the number is infinite. Suppose the system consists of two finite masses describing circles and of an infinitesimal body revolving around one of them. It is clearly immaterial where the center of gravity of the system is located, and since it is defined by three independent coördinates, if there is any periodic solution at all, there is a three-fold infinity of them. The plane of motion of the finite masses is also arbitrary, and consequently, since the position of a plane through a point is determined by two quantities, the infinity must be five-fold. The orientation of the finite bodies in their plane at the origin of time is a matter of indifference, and hence the infinity is six-fold. Finally, if a periodic orbit exists in the case under consideration, it is

clear that it makes no difference what part of its orbit the infinitesimal body is in at the origin of time. Consequently the infinity is seven-fold. But this seven-fold infinity of periodic orbits all depends upon what we may well consider a single one, for geometrically it is unique except for its location and orientation. The theorem of Poincaré is that there exists an infinity of geometrically distinct periodic orbits of the class under consideration. They depend upon a single arbitrary parameter such as their linear dimensions or their periods.

The conclusion was only proved to hold when the second finite mass is sufficiently small. There are several other classes of periodic orbits, each having infinitely many members in approximately the same sense.

It is improbable that the planets move in strictly periodic orbits, but Poincaré has conjectured, without being able to prove it, that periodic orbits exist which differ from any particular orbit as little as one pleases for as long a time as one pleases. Since the expressions for the periodic orbits converge for all values of the time, at least for convenient values of the parameters, it is clear that now there is hope of building the theories of celestial mechanics with full rigor. As Poincaré says, these periodic orbits constitute the single breach into a region hitherto considered inaccessible. While the work of Poincaré was not developed in a form suitable for practical applications, there is little doubt that the time is now ripe for building anew the theories of the motions of the heavenly bodies on the foundations he has laid. The last word from the practical point of view was not said any more by Laplace than it was by Newton.

Another very celebrated paper by Poincaré is on the figures of equilibrium of rotating fluid bodies. In recent years it has been very much quoted by popular and semi-popular writers on astronomy. Unfortunately, exactly what Poincaré proved very often has been imperfectly understood, and there are prevalent misconceptions as to the precise scope of his conclusions. Hence they will be described briefly. He discussed only homogeneous *incompressible* fluids subject to no forces except the mutual gravitation of their parts. He considered an infinite series of these masses differing only in their rates of rotation. It was known from the work of Maclaurin that for slow rotation an oblate spheroid is one figure of equilibrium, and from that of Jacobi that a certain three-axis ellipsoid is also a figure of equilibrium. Suppose that for a certain rate of rotation

the shape of the figure of equilibrium of Maclaurin or Jacobi is known. The method of Poincaré consisted in taking a rate of rotation a very little different from the given one and a body differing from the corresponding figure of equilibrium a little, but in an entirely arbitrary fashion. Then the conditions that it should be a figure of equilibrium were imposed. It is known that they can always be satisfied because the figures of equilibrium of Maclaurin and Jacobi are known to exist for all values of the rotation not too great. If the solution is unique, there is no other solution having nearly the same shape; but if it is multiple, there are other solutions. A point where the solution is multiple is called a "point of bifurcation". It is as though one were traveling a path and should stop at a point and examine the vicinity in every direction. If the condition that he should find a path could be satisfied in but one way, there would be but one path through the point; but if it could be satisfied in more than one way, there would be two or more paths crossing at the point of bifurcation. Poincaré proved that along the path of the Jacobian ellipsoids there are infinitely many points of bifurcation, or places where there are other forms of equilibrium approximately ellipsoidal in shape. That form which is like the least elongated of these ellipsoids in shape he called the *apioid*, because it had one end smaller than the other after the manner of a pear. But the later detailed computations of Sir George Darwin have shown that it is extremely elongated and that it resembles a cucumber, rather than a pear, in shape. In proving these results Poincaré employed some of the methods which he used later in the problem of three bodies.

It will be noticed that Poincaré's assumptions of homogeneity and incompressibility both violate the conditions found in nature, though it may be supposed that the results for the actual bodies would be analogous. The difficulties of the subject are so great that such simplifications of the problem are certainly excusable at present. But a physical body does not have all the rates of rotation possessed by the series of masses considered in the investigation. It is true that if a rotating body is not incompressible and contracts, it will rotate more rapidly. However, with contraction there is an increase of density which tends, because of the increase of gravity, to make the body more nearly spherical. An investigation which Poincaré did not undertake shows that if a rotating spheroid contracts in such a way as to remain homogeneous it will indeed become more oblate, but that it will change

its shape very slowly. The amount of contraction necessary to bring any known celestial body near the first point of bifurcation is so great as to assure their perpetual stability. And even if any body should become an apioid, there is absolutely no proof that it would divide into two parts, for no one has shown that the apioid separates into two masses, and much less that it passes through a series of stable figures in the process.

It is nearly twenty years since the work of Poincaré on the problem of three bodies was first published, and it is as yet very little known, especially in this country. It has sometimes been claimed that this is because his style is obscure. On the other hand his popular and philosophic articles have always been considered models of clear and forcible composition. Is the mathematical style of Poincaré really obscure? Unquestionably there is a difference of opinion on the subject. A writer may be hard to follow because he does not have clearly in his own mind the line of thought he wishes to develop, and because he wanders on unessentials and in an illogical order; or, he may seem obscure if his ideas depend upon a wealth of information and fit only into a horizon which are far beyond his reader. In the former way Poincaré is never obscure; in the latter, perhaps often. The order of ideas he introduced into celestial mechanics had been hitherto quite foreign to astronomy, and it is not strange that astronomers found it impossible to understand him. But when one is prepared by mathematical education to comprehend the subject at all, he is amazed at the directness and clearness with which Poincaré proceeds to the essentials. Few writers on mathematics, if any, have equaled him in explaining the relations of the new and the general with the known and particular, and in showing the steps he has taken in making a discovery. In these respects he is the opposite of, for example, Gauss and Hermite. They leave their readers wondering how they ever first reached their conclusions; Poincaré often leads his to the goal so simply they wonder that they never arrived there alone. It is true that at times he moves swiftly when once on the way, and more bridges across the rough places would be helpful, because it is hard for ordinary mortals to keep pace with a giant; but to those who can rise with him to the heights necessary to obtain a general view of the problem he discusses and to discern the general direction of procedure, the way seems straight and is never entirely dark. Considering the

great variety, generality, and importance of the ideas he introduced into celestial mechanics, I personally consider him without a superior in clearness and style.

In recent years Poincaré has devoted a great deal of attention to the philosophy of mathematics and science. Many of his papers and addresses have been issued in book form in three volumes, the Value of Science (1905), Science and Hypothesis (1906), and Science and Method (1909). The topics considered in these books were such difficult ones, to mention only a few, as, "The Future of Mathematics," "Mathematical Invention," "Non-Euclidean Geometry," and "The Relativity of Space."

Notwithstanding the difficulties connected with all of them, and the abstractness of some, he set forth his profound ideas in such a brilliant and luminous style that it is a delight to follow him. More than 50,000 copies of the French editions of these books have been sold, and they are strongly recommended to all who have not yet read them.

The philosophical ideas of Poincaré have been by no means universally accepted. Doubtless one's philosophy reflects strongly his own intellectual experiences and himself. To the experimenter and pure observer of natural phenomena the things with which he deals seem wonderfully real. It is not, of course, suggested that he may not be dealing with realities, but only that they may be altogether different from what he thinks they are. For example, before the days of Thomas Young the "corpuscles" of light probably seemed fully as real and certain as ether waves did later, and now there are suggestions that there is no ether. At least some of the vivid pictures which physicists have had about light have not corresponded to the realities. On the other hand, one who has been trained in mathematics, who has thought deeply and has appreciated the essential rôle of hypotheses, who has observed that much of his science is concerned with relations among things which are not, and need not be, fully defined, will suspect that in physical science also there is much which is definition and partially indeterminate. I say only partially indeterminate because our experiences impose relations which must always be fulfilled in our theories, at least with a certain degree of approximation, but it is doubtful if our experience is wide enough in a single domain fully to define any physical entities. The facts regarding the reflection and refraction of light were explained under both the corpuscular and the undulatory theories of light, and they must be explained under any future

theories. Now Poincaré shows, I think, that there are much larger elements of definition and convention, not only in physical science, but also in mathematics, than has generally been supposed. In order to help make the matter clear I will illustrate it by changing something that is ordinarily considered very fundamental and certain, and will point out that we could not experimentally prove the new system incorrect.

We use the rotation of the earth with respect to the stars as the fundamental means of measuring time. A large part of those physical relations which are not purely statical involve the time, and those which are of such a nature that they can be verified by experiment are expressible in the form of equations. For example, the distance a body falls from rest in a given time is the time squared multiplied by one-half of the constant of gravity at the point.

Now the earth also rotates with respect to the sun, but at a variable rate. If we let t represent ordinary time and T the time measured by the rotation of the earth with respect to the sun, we find that T equals t plus an infinite series of small periodic terms in t; and t can be expressed similarly in terms of T. Suppose now that T is called time. Our powers of estimating time are not so accurate that we could detect the difference without instrumental assistance. Instruments, such as clocks, of course would show that something is wrong unless some other change were made to harmonize things. In order to show that harmony between theory and observation can be restored, consider the simple problem of the falling body. The formula for the distance in terms of t is known; and from the relation expressing t in terms of T the formula for the distance in terms of T can be obtained. It follows from the method of its derivation that it will agree with experience when time is defined by the rotation of the earth with respect to the sun. The second derivative of the expression for the distance fallen in terms of T gives the acceleration, or law of force, which must be used with the new time. The first term is a constant the same as when t is used for time, but there are also infinitely many other small periodic terms in T. Consequently the force of gravity becomes a function of the time which the body has been falling, and our mechanics becomes correspondingly complex. This sort of a mechanics is repulsive, though there are somewhat analogous things in the distortion of imperfectly elastic bodies where the forces of restitution depend upon the length of time the body has been deformed. The question here

is not whether the mechanics is simpler or more complex, attractive or repulsive, but the point is that theory and observation are in harmony. It is clear from the fact that the new mechanics is a transformation of the old that if we use the correct relation between T and t all theory and experience will be in accord with the same degree of accuracy as at present. Consequently there is an element of definition in time, and naturally we take that which makes all the relations involved the simplest. Similar things are true in space, where Poincaré took his illustrations, and in nearly everything else. It must not be inferred from this that Poincaré denies the existence of a universe beyond our minds, or that we can learn much about it. In showing the limits and limitations of our knowledge he reveals its vast extent and variety. His philosophy is not one of despair; it does not depress. There may be for some a little shock on learning that in many things there are elements of definition and convention where it was supposed all was established by experience; but when this has passed, the wholesome optimism of his views becomes manifest. He is seen to be not a cold logical machine, or a mystic, or a visionary transcendentalist. He has a remarkable knowledge of, and interest in, the so-called practical things of life. He does not despise nor underestimate the forms and arts, but he recognizes that esthetic satisfaction has its fundamental basis in utility. Sometimes the utility is expressible in terms of physical things, and sometimes it is in economy of thought; sometimes it is directly evident to our perceptions, and sometimes indistinctly it lies tangled up in the accumulated experiences of the race.

Perhaps the broad catholicity of the philosophy of Poincaré can be illustrated by a few lines respecting his views on the scope of mathematics and on the purpose of science. He recognizes the indebtedness of mathematics to the problems of the physical world. Probably no one knew better what whole domains of mathematics originated in this way. One of the aims of mathematics, he said, should always be to help us to understand, interpret, and control the inanimate universe about us. But there is another equally legitimate, and often opposite, side. It is the philosophy of mathematics, that which consists of the investigation of the postulates of mathematics and of the types of mathematical reasoning. Besides laying the foundations of the science more securely, it is valuable because mathematics is a product of the mind, and to study its nature is to study the mind. Poincaré rejoices in the utility of science. He

recognizes that it has changed the world and that it has contributed enormously to the comfort and good of mankind. But to stop there is to fail to remember that we are thinking beings, to miss the best and most inspiring part of the vision. Its highest aim should be, and is, not to feed us better and to clothe us better, but to make us so efficient that we shall have more abundant leisure for reflection and the pursuit of truth.

It has been stated that Poincaré often shows in his memoirs by what means he has been led to a discovery. But he has gone further and done something no other mathematical genius has done; he has attempted to analyze and explain for us his own mental processes. His discoveries always depend upon a period of reflection and struggle for the correct combinations of things. Many times he is baffled long before succeeding. For example, he had not been able to prove the main theorem of his last paper though he had worked on it for two years. It should be noted that he established its correctness in many special cases and published it in its incomplete form because, as he said, he might not be able to return to it. Success did not always follow, if at all, immediately after a period of reflection. He cites instances where, after laying a subject aside for a time, his mind suddenly reverted to it and the solution flashed into his consciousness. When it came he had no doubt of its correctness, though the logical connections were by no means complete. He interpreted this as meaning that the subject had been developed in the subconscious activities of his mind, and came to the surface of his consciousness only when the conclusion was reached.

Poincaré died at fifty-eight. The whole world regrets that twenty years were not added to the thirty-three which were so filled with his achievements. It does not seem right that fate should so early have stopped forever that brilliant mind. We say he lived only fifty-eight years, though for a thinking being time is not measured by a circling world, but rather by the number and nature of the thoughts that flash in his consciousness. Measured in this way his life covered an enormous span. This universal genius made the essence of all of mathematics and physical science and much of philosophy his own. He seemed to have encompassed the present universe of ideas. More than that, he focussed his great reasoning powers on the problem of "how the heavens and the earth rose out of chaos," and by this means virtually extended his life back beyond history and the existence of the habitable earth, and also

projected it equally into the future: by his logic he almost achieved immortality. Poincaré has set a mark of accomplishment which will probably not soon be equaled. He has taken his place among the few whose names do not lose their luster with age. In Westminster Abbey lie buried England's noblest dead. There over the tomb of Newton is a tablet on which is inscribed "Mortals congratulate yourselves that so great a man has lived for the honor of the human race." How appropriate this simple, dignified, and expressive sentiment would be for the tomb of Poincaré!

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A BRILLIANT NIGHT AHEAD.

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There are a number of things which enter into the problem of the degree of brilliancy of a moonlight night. Every one knows that the dullest moonlight extinguishes the light of many stars by brightening the sky. But all are not familiar with the various elements which work together or at cross purposes in determining the splendor of a particular night and of a particular hour or even minute of that night.

While the moon itself possesses no inherent brightness, that luminary merely acting as a reflector for the sun, there are, from our terrestrial viewpoint, several conditions which determine its glory. These are: (1) its phase—whether crescent, half moon, gibbous or full; (2) its altitude, not merely with reference to rising and setting, but also with reference to its declination, or north and south latitude; (3) its distance from the earth—perigee and apogee, and the variations in each of these; (4) the earth's (and moon's) distance from the sun—perihelion and aphelion; (5) the condition of the atmosphere at the time; (6) the reflecting power of the landscape.

About the 23rd and 24th of December, there is to be a remarkable combination of several or possibly all these elements, conspiring to give us one of the most brilliant moonlight nights imaginable. Full moon occurs on Dec. 23 at 11:30 P.M., Eastern time; this is the phase at which the moon sheds the greatest amount of light upon the earth. Though the moon's visible

face is only doubled in passing from half moon to full, its light is multiplied 12 times. And Pickering makes the light of full moon equal to that of 100,000 stars of 0.0 magnitude, like Capella.

The moon reaches its greatest altitude in 24 hours in crossing the meridian, as the sun does at "high noon." This it will do for easterners only half an hour after the moment of full moon; and even for westerners there will be but slight difference; that is, the moon will be about as full when crossing their meridians. The highest declination of the moon is reached on the 24th, —only the next day,—at which time the moon will be the highest for the year, reaching a northerly declination of 28 degrees and 24 minutes, as contrasted with its lowest for the year on June 28 last, when its southerly declination was 28 degrees and 15 minutes. Here we find the moon 56½ degrees farther north than it was June 28, which means 113 moon's breadths nearer the pole of the heavens, and higher than the sun is ever seen. It will be almost as high as this when it is full, and it will be but slightly past full when it is as high. Hence midnight of either Dec. 23 or 24 will place the moon well toward the zenith, almost enabling us for once to make our escape from our shadows. And inasmuch as the higher any body is, the more its beams are freed from the necessity of breaking through the dense portions of the atmosphere, with their accompanying mists and dust, so this extremely elevated position of the moon will enable it to give us the fullest benefit of its full-orbed glory.

The distance of a light has also much to do with the brightness of its rays when they reach us. Double the distance and you quarter the light: halve the distance and you quadruple the light. Now the moon's distance from the earth is far from uniform as it alternates between perigee, its nearest, and apogee, its farthest. A difference in its distance of more than 32,000 miles out of an average of 239,000 miles, makes a marked difference in its light. The moon, at any particular phase, yields 0.449616 more light at its nearest than at its farthest. Now the moon is approaching its perigee, or nearest point, the night it becomes full, is still nearer the next day when highest, and reaches it the following day, the 25th, so close a date to that of full moon and that of highest moon, that it must be counted in as entering into the conditions that give lustre to the midnight hour of either the 23rd or 24th.

It also so happens that the earth itself, with its attending moon, is approaching perihelion, the earth's position nearest

to the Sun, reaching the same Dec. 31, only a few days later, at which time the two globes will be 3¼ million miles nearer to the sun than on July 4, when at aphelion, their farthest position. Now the amount of light which the moon can reflect upon the earth depends on the amount which it receives from the sun. And when the earth is at perihelion it receives 0.069156 more light than when at aphelion. The moon shares in the benefit and its work of reflection is correspondingly brilliant.

To all this may be added the condition of the atmosphere on the nights in question, concerning which no definite prediction can be made even 24 hours in advance. But there is at least room for hopefulness that a good sharp north wind will make the sky crystalline in its clearness; some regions will of course be more highly favored than others, and some are usually so.

With respect to the sixth point, namely, the reflecting power of the landscape—that which, in the case of a planet, we call the albedo—manifestly some localities will be better than others; for example, the light sandy soil of certain regions will reflect the moonlight, just as it gives a glare to the sunlight; while the dark mucky regions of others will absorb and measurably kill the moon's rays as fast as they touch the earth. But, at this season of the year, at least in all northerly latitudes, we have every reason to look for snow, which, like charity, will cover a multitude of the sins of the soil, and give us the most perfect reflecting surface.

These several elements, entering into an extraordinary combination, invite us into the open at the midnight hour of Dec. 23 and 24, to witness a fresh and unusual illustration of the ancient fact that "the heavens declare the glory of God, and the firmament showeth his handiwork."

SUNS OF AUTUMN.

Once more resplendent with supernal fire
Auriga's monarch rules the eastern sky,
Whilst azure Vega midst her jeweled Lyre
Reigns o'er the west with slowly waning eye;
Once more yon Bull's eye gleams with ruddy ire
And Pleiades begin to sparkle high;
Again Prince Perseus rises high and higher,
And Sea-Goat's reign is slowly drawing nigh.

CHARLES NEVERS HOLMES

Hotel Nottinghan, Boston, Mass

PLATE XXXIV

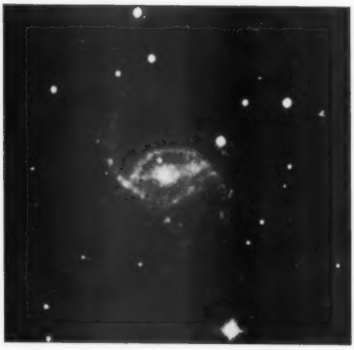


FIGURE I.

THE SPIRAL NEBULA N. G. C. 5021.

Crossley reflector. Exposure 3^h

FIGURE II.

THE SPIRAL NEBULA N. G. C. 1300.

Drawn from a Crossley photograph.

PLATE XXXV

THE HELICAL NEBULA IN AQUARIUS

Photograph by H. D. Curtis with the Crossley reflector. Exposure 4^h 10^m

THREE INTERESTING SPIRAL NEBULAE.*

HEBER D. CURTIS.

A number of photographs have been made during the past year with the Crossley Reflector of nebulae hitherto unphotographed, and in the course of this work three nebulae of rather unusual form have been discovered. Figure I, Plate XXXIV, shows the spiral nebula N.G.C. 5921 ($\alpha = 15^h\ 17^m.0$; $\delta = +5°\ 26'$). It has a nebulous central star, and from this extends on each side a nearly straight line of matter, from the ends of which spring two strong spiral branches; there are also a number of fainter spiral whorls. The central oval is about 1'.6 long. The photograph from which the cut was made was taken on June 10, 1912, with an exposure of three hours. It somewhat resembles N.G.C. 1300 ($\alpha = 3^h\ 15^m.2$; $\delta = -19°\ 46'$), shown in Figure II, which is a drawing from a negative exposed two hours and ten minutes on September 16, 1912.

The nebula N.G.C. 7293 ($\alpha = 22^h\ 24^m.3$; $\delta = -21°\ 21'$), shown in Figure III, Plate XXXV is a most interesting object, and, so far as I know, entirely unique among nebular forms.† Discovered before 1824 by Harding, visual observations give absolutely no idea of its true form, and it is described in the N.G.C. of Dreyer as !pF, vL, E or biN (Auw. 48). It is 13' in extreme diameter, making it the largest ring-formed object known, but from the original negative it is easily seen to be about two turns of a helix. The negative from which the cut was made was exposed four hours and ten minutes on September 9, 1912. I would suggest that this interesting object be referred to as "The Helical Nebula in Aquarius."†

* Reprinted from Publ. A.S.P. for October, 1912.

† Professors Holden and Schaeberle, from visual observations of the small planetary nebula N. G. C. 6543 ($\alpha = 17^h\ 58.^m6$; $\delta = +66°\ 38'$) in M. N. *48*, 388, 1888, suspected a similar helical formation of this planetary. They state, "it appears to us at least probable that the real disposition of the brighter parts in space *may be* in the form of a helix." Careful examination of short exposure photographs, however, indicate that the structure of this planetary is that of a very compact spiral, with two very strong whorls. Dr. Burns, in *Lick Observatory Bulletin 6*, 192 has suggested a possible helical formation for the Ring Nebula in *Lyra*.

ASTRONOMY AS RECREATION.

ALFRED RORDAME.

In school, as a little boy, I had my first introduction to astronomy, when the old fashioned geography in use in those days was placed in my hands. The preface contained a short description of the solar system and the earth as a planet. It opened a vista of grandeur to my youthful mind that has grown with the years, until the contemplation of the universe has, by the aid of the telescope, come to be a source of intense pleasure, as well as affording a means of refuge from all the

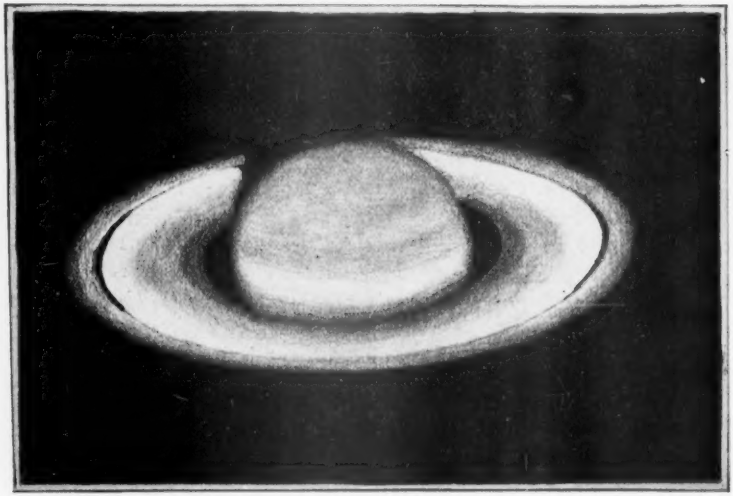


FIG. 1.

SATURN—Sept. 4, 1912—4 A.M., MOUNTAIN TIME. DRAWING BY A. RORDAME.

sordid cares and vexations of every day life. I hold that it is a duty we owe to our families as well as to ourselves, to try to beautify our lives as much as possible. As a nation, we are continually grubbing in the dirt of politics and business instead of exercising the esthetic qualities of our minds; the qualities by which we are enabled to look out upon nature, and by which alone we are distinguished from the other animals.

Possibly the fact that astronomy has so few votaries in our cities may be accounted for by the dullness of our skies. The intense electric illumination of our streets overpowers the soft radiance of the stars to such an extent, that the "man in the street" in glancing up to the heavens is perhaps enabled to see the brighter of the planets and the first magnitude stars; but that is about all. Of course we take it for granted that he knows the moon shines once in a while.

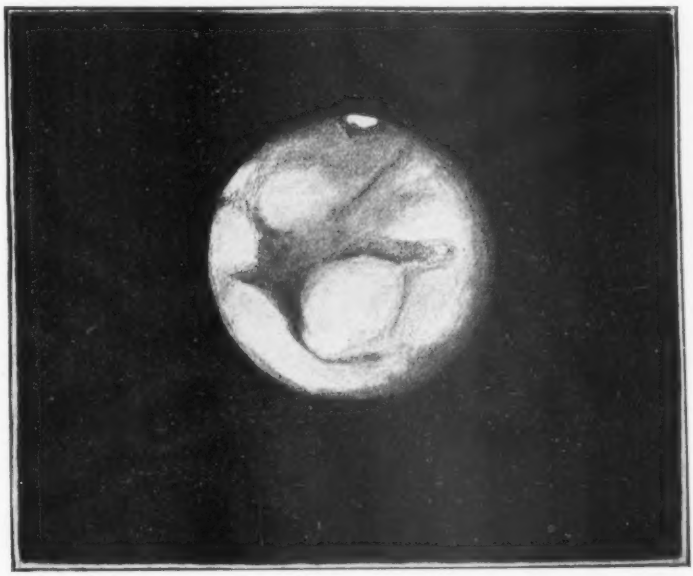


FIG. 2.

MARS—Aug. 5, 1907—8:20 P.M., MOUNTAIN TIME. Power 350.
DRAWING BY A. RORDAME.

We city-dwellers who occasionally worship at the shrine of Urania, know only to well what it is to suffer from the dust and smoke nuisance and when in spring and autumn from some elevated point we have seen the heavy pall of smoke hanging over the streets, the hopelessness of performing any work of real value to astronomy has become a conviction. So we have come to the conclusion that the pursuit of the science as a pleasant hobby and recreation in leisure hours is as much as we can expect.

The drawings and photographs submitted herewith have been obtained during moments of relaxation from business, and sandwiched in between electrical experiments and the cultivation of flowers and music.

Fig. 1 is a drawing of Saturn, and shows how the planet looks in a 6-inch telescope with a magnifying power of 350 diameters. The drawing is the result of impressions gained during moments of best definition. In all planetary observations, when the atmosphere is unusually steady, the image seems to be illuminated to a sufficient degree with this power. The different shadings were seen as represented; but I must confess that, look as I might, not a trace of a division in the ring was seen where Encke's is supposed to be.

FIG. 3.

MARS—Aug. 5, 1907—9:30 P M. MOUNTAIN TIME. DRAWING BY A. RORDAME.

Figs. 2 and 3 are views of Mars during the opposition of 1907. Quite a number of drawings have been made, during this and the succeeding oppositions; but no great amount of detail can be seen on this planet with an aperture of only

FIG. 5. HALLEY'S COMET, MAY 11, 1910,
4: 30 A. M.

FIG. 6. BROOKS' COMET 1911 *c*, NOV. 1, 1911,
5 A. M.

PHOTOGRAPHS BY ALFRED RORDAME WITH A PORTRAIT LENS.
The guiding is done entirely by hand.

6 inches. Fig. 3 shows the effect of rotation during one hour and ten minutes and also the displacement of the markings due to the inclination of the planet's axis.

Fig. 4 shows the moon at first quarter photographed in a 6-inch telescope. The image on the original negative is about ½-inch by $\frac{3}{16}$-inch. No scientific value is attached to a photo-

FIG. 4.

graph of this kind, but much pleasure is derived from experimenting with different plates and times of exposures. A quick plate and short exposure seems best in this case. The picture is enlarged from a negative made on a Seed 30 plate with an exposure of one tenth of a second.

Fig. 5, Plate XXXVI, is Halley's comet rising above the Wasatch Mountains. The exposure here is short, only fifteen

minutes, as the dawn was approaching. The lens used was a Dallmeyer Portrait of two-inch aperture and six-inch focus. In this and all other photographs taken by me, the guiding has been done entirely by hand, the camera has been attached to the telescope and crosswires used in the field of view.

Fig. 6, Plate XXXVI, Brooks' comet (1911 *c*), with the planet Venus and a meteor. While guiding the camera a meteor fell and illuminated the field of view. In its flight it impressed itself upon the plate. The intense brilliancy of the morning star has resulted in a reversal of the image. The star below the head of the comet is γ Virginis. Exposure 30 minutes; Darlot lens, 2½-inch aperture, 10-inch focus; Lumiere Sigma plate.

Fig. 7, Plate XXXVII. The Pleiades, famous in legend, and according to Miss Clerke "the meeting place in the skies of mythology and science." A peculiar sacredness has in my mind always been associated with this, the most vivid and picturesque asterism in the heavens. It has been calculated that their light takes 190 years to reach us, and our own sun would be surpassed in brilliancy by 50 or 60 of the Pleiades, by Alcyone 170, by Electra 83 and by Maia 70 times. The photograph shows the nebulosities surrounding the stars quite plainly and was obtained with an exposure of 1 hour and 30 minutes.

Fig. 8, Plate XXXVII. The Milky Way in Scutum Sobieski. Exposure 1 hour. The portrait lens, which takes in so large an area of the sky, gives quite the best idea of the extent of this, one of the most wonderful star clouds in the heavens. Its spiral formation is quite evident. Imagination is staggered by the immensity of this formation, when we reflect that the whole solar system transported to this distance would barely occupy the space contained in the very smallest star dot.

Our own insignificance becomes painfully manifest upon contemplation of this fact; and further, that the earth is absolutely invisible to an inhabitant of a planet, should it exist, revolving around Alpha Centauri. And yet, mankind stew and worry about their own little affairs, and are ready to kill one another for a difference of opinion. In the Great Universe the earth is *unknown* and the sun itself is merely one of the innumerable small luminous points helping to make up the misty radiance we call the Milky Way.

Salt Lake City, Oct. 10, 1912.

FIG. 7. THE PLEIADES, OCT. 27, 1910.
Exposure 1^h 30^m

FIG. 8. THE MILKY WAY IN SCUTUM SOBIESKI,
Aug 10, 1912. Exposure 1^h

PHOTOGRAPHS BY ALFRED RORDAME WITH A PORTRAIT LENS.
The guiding is done entirely by hand.

NOTE ON THE BINARY SYSTEMS OΣ 536 AND OΣ 341.

R. G. AITKEN.

The double star OΣ 536 was discovered by Otto Struve in 1852, and three rather discordant measures in that year and the year following gave a distance of 0″.30± in position angle 341°.9.

In 1859 the same observer failed to see the star double, and therefore thought that a conjunction had taken place; but apparently he examined it on one night only. The measures in the following years, to 1905, gave angles varying from 140° to 177° (with occasional reversals of quadrant), the majority falling within the ten degrees from 160° to 170°. Burnham* has shown that there is no reason to suppose that the distance varied sensibly in this interval, a value of about 0″.30 being most probable. At his request I examined and measured the pair with the 36-inch refractor in 1896 and 1897, and again in 1905. My measures agreed with those made elsewhere, and with those of Hussey, in indicating little or no change. The two components, also, were found to be so nearly equal in brightness that reversals of quadrant in published measures would have little significance.

From all of this evidence the pair had come to be regarded as having little interest as a binary system, though the large proper motion, 0″.40 in 111°, which the two components possess in common, definitely established their physical relationship. But on September 21 of the present year I was unable to see the star double with a 520 power eyepiece on the 36-inch refractor. After identifying the star with certainty I examined it with higher powers, and with a power of 3000 could clearly see that it was double but that the distance was only 1/10 of a second of arc. Settings for position angle ranged from 126° to 139°. On October 12 I secured another measure with a power of 2600, the result being 157°.6 and 0″.13. The elongation on this night could be recognized quite certainly with a power of 1500.

In OΣ 536, then, we have a binary system in which the apparent distance shows little or no change for a term of many years, and then changes with great rapidity, while the position angle changes but little, or not at all.

* General Catalogue of Double Stars II, p. 1009.

It may be recalled that OΣ 341 * is a system presenting similar phenomena. The measures from 1843 to 1852 gave a separation of 0″.46 in 92°.3; those from 1864 to 1886, one of 0″.41 in 87°.8. It was not measured in the periods 1852-1864 and 1886-1898; but in the last named year Hussey could not separate it with the 36-inch telescope. At his request I also examined it with that telescope and could see no elongation with any power. In 1899 it was readily measurable, Hussey's result being 0″.18 in 86°.2. Since then the angle has changed very little but the distance has increased,—rapidly for a year or two and then more slowly. My measure in 1910 gave 0″.48 in 93°.2.

Clearly these two systems (and probably many others, as, for instance, β 949,) move in orbits whose planes, like that of 42 *Comae Berenices* (Σ 1728,) are practically perpendicular to the plane of projection, though the inclination is probably not precisely 90°, as no eclipse or variation of light has been observed in any of them.

The distance change in the two systems under consideration differs from that in 42 *Comae* very much as the light variation in an Algol system differs from that in a Cepheid or Geminid variable star. Instead of changing continuously, it remains practically constant for a long interval and then goes through a complete cycle† in a comparatively short period. Obviously the orbits must be greatly elongated and the major axis in each must be very nearly parallel to the line of sight.

In computing the preliminary orbit of such a system one may assume the line of nodes to be coincident with the average of the measured position angles, and the inclination to be 90°. Careful measures of distance through the cycle of change at each of three or more conjunctions will give the true period with precision and will also enable us to discriminate between the times of periastron and apastron passage, the cycle being completed more rapidly at the former time. But only a rough approximation to the value of the eccentricity can be gained in this way, and the problem of determining this element with greater precision presents unusual difficulties. At first thought it might be assumed that measures of radial velocities

* See Hussey's notes in Publ. A.S.P. Vol. 10, p. 121, 1898 and Vol. 12, p. 38, 1900.

† Strictly speaking, only half a cycle, but the two maximum values of the distance seem to be equal.

would solve the problem. But in these systems the two components are practically of equal brightness and apparently of the same color. Probably, then, they are of the same spectral type and do not differ greatly in mass. The relative orbital motion, too, will be slow except at periastron, at which time it will b almost entirely at right angles to the line of sight. As the two components are too close together to be photographed separately, the spectrum will be that of the integrated light of both and will yield only the systemic velocity. The determination of the major axis is dependent, of course, on that of the eccentricity, the minor axis being given by the distance measures.

Doubtless it will be many years before reliable orbits of such systems can be computed, but this ought not to detract from the interest taken in them. The very fact that they present unusual difficulties should stimulate our interest. One obvious moral to be drawn from these two instances is that it is not safe to neglect close double stars simply because the measures of many years give little evidence of orbital motion. That such pairs are true binary systems is beyond question, but only careful and frequent observations will give us the data necessary to compute the orbits.

Lick Observatory, Oct. 19, 1912.

OBSERVATIONS OF VARIABLE STARS MADE AT THE VASSAR COLLEGE OBSERVATORY.

CAROLINE E. FURNESS.

The Observatory of Vassar College is preparing for publication its series of observations of variable stars, in number about five thousand. While the work is by no means finished, it has progressed so far that an account of the methods employed can easily be presented, and to give this in outline is the purpose of the present paper.

These observations were begun in 1901 by Professor Mary W. Whitney and continued until 1910 when they were interrupted by illness. They were taken up by the present writer in 1909. Contributions have been made by other assistants and students at various times connected with the Observatory.

The equipment of the Observatory is well suited to variable star observations, because it includes several telescopes of different apertures which can be used to supplement each other, the selection of the instrument depending upon the brightness

of the star under observation. The principal instrument is the twelve-inch telescope. Next to this the one most in use is a Clarke five-inch telescope mounted with circles. This instrument which was presented to the College by one of its alumnae is an excellent one with very fine definition. The shelter covering it has a gable roof, the two halves of which can be run off on tracks, leaving the sky entirely unobstructed. The advantage of this is obvious when we consider the number of settings which must be made during an evening's work, and the different regions of the sky toward which the instrument is pointed.

In addition to these two instruments the Observatory possesses a mounted four-inch telescope, and two portable three-inch telescopes. A third three-inch, the personal property of Professor Whitney was used by her during the summer months when the college was closed.

The twelve-inch telescope was provided with a photographic wedge photometer, which was used extensivly by Professor Whitney. She found this to be somewhat unsatisfactory, principally because the artificial star could not be made to resemble the real star. Furthermore, for long period variables it was found that visual comparisons were equally accurate, while as regards short period variables for which it is especially suitable, the time at her disposal was not sufficient for the necessary consecutive observations. After two years of trial its use was discontinued.

In making out the observing program, several points were taken into consideration. Long period variables were much more extensively observed than short period variables, though the latter were by no means excluded from the list. Since the list of the long period variables observed during the past ten years is somewhat lengthy, it seems advisable to enumerate the reasons for their selection somewhat in detail.

1. A fairly large number was selected from the principal ephemerides so that they might pass through a maximum during the period of observation. At first these predictions were taken from a list published by Chandler in the Astronomical Journal but of late years those of Hartwig in the Vierteljahrsschrift were found to be more convenient. This plan of observation would obviously require a long list of stars, partly because of their position in the sky, and partly because during the three summer months, when the three-inch telescope was in use, only bright stars could be observed. The summer variables had to be easily identified because the three-inch had no

circles for setting. Observations of these stars were continued on either side of the maximum as long as was possible. In many cases quite large discrepancies were found between the observed and predicted maximum.

2. The minima of many of these same stars were observed by the writer with the twelve-inch telescope. Additional stars were selected from Hartwig's list for which the minima were marked unknown.

3. Many new variables were taken up from their announcement in the *Astronomische Nachrichten* or in the *Harvard Circulars*. Some of these turned out to be of short period or irregular.

4. SS Cygni had a prominent place, and was observed more frequently than any other star. It was an easy object for the three-inch during the summer time.

5. Several well known variables which were very bright at maximum were added from time to time, because they were particularly adapted to the students and other beginners.

At this point a brief mention might be made of the method of coöperation between the observers with the twelve-inch and five-inch telescopes. When a star, which was on the observing list for the five-inch telescope, became fainter than 11.5 or 12.0 mag., it was passed over to the observer with the twelve-inch and *vice versa*, as stars became too bright for easy comparison with the twelve-inch they were placed on the list for the five-inch telescope.

It will next be in order to mention the maps used for identification of the variables, and the selection and location of the comparison stars. The method of determining the magnitudes will be discussed in another section. The most useful maps were those of Hagen, and, indeed, these are really indispensable to an observer who has a telescope large enough to show faint stars. Too much can not be said in praise of their accuracy. Probably we have used a hundred of his maps without finding half a dozen discrepancies on comparing the maps with the sky. Nevertheless these have not been sufficient for comparison at times of minimum, and we have added to many of them, faint stars near the variable. In order to identify these for later reference, particularly in regions where the stars are very numerous, recourse was had to the Parkhurst photographs. These are photographs of the Hagen regions made with the two foot reflector at the Yerkes Observatory

and then enlarged. They give stars much below the limit of the twelve-inch telescope and hence are absolutely reliable.

It was hoped that the Wolf-Palisa photographs would be of great assistance, but an examination of them proved a little disappointing. Not a great many of them have yet appeared, and though they contain very faint stars the scale is so small and so different from either the Hagen or the D.M. charts that they would have to be redrawn on a larger scale to be of real use with the telescope.

In addition to the Hagen maps, extensive use was made of the Harvard photographs which have been so generously furnished to variable star observers by the Director of the Observatory. These have marked on them the magnitudes of the comparison stars which were used at the Harvard Observatory. Like the Hagen charts, these frequently failed to show the images of the faintest stars used, and hence the additional stars required were marked on them by the observer from their position in the sky.

When neither Hagen chart nor Harvard photograph was available, the Durchmusterung charts were the final resort, all additional stars necessary being drawn in by the observer.

Occasionally, maps by other observers have been published in the *Astronomische Nachrichten* or various Observatory publications, and have been adopted by us or were used for comparison.

It has not been our practice to use the original charts at the telescopes. In the case of the D.M. and Wolf-Palisa photographs this was impossible on account of their awkward size. In the case of the Hagen charts, tracings were made and to the stars were attached their numbers, and sometimes the magnitudes, while on the back of each was written any other information which was useful to the observer, or additional maps and drawings, and lists of magnitudes on Hagen and Harvard scales.

The identification of the comparison stars was made by means of the Hagen number or the Harvard letter or number in all cases where the comparison stars were found in their lists, but all additional stars had to be located accurately in order that other observers of the same variables might identify them with their own comparison stars. Several methods were used in accomplishing this, the choice depending upon the kind of map used as a basis.

At first for the faint ones, 12.5–13.3 mag., a square bar occulting micrometer, such as was devised by Dr. S. C. Chandler,

was used, because it was assumed that these stars were too faint to bear the illumination of the filar micrometer. Quite accidentally one evening, while the filar was being used for other purposes, it was found that stars as faint as 13.3 magnitude could be bisected quite easily, and thereafter the square bar was discarded. Observations can not be made as accurately with it and the reduction is much longer.

However, the faintest comparison stars could not be located in this way, and other devices had to be found. When the Hagen charts were used, the additional stars were located by alignment with other stars, and their $\Delta\alpha$ and $\Delta\delta$ read from the map. If Harvard photographs were used, the stars were plotted on them and the positions measured on the photograph. A few stars were obtained by measurement on the Wolf-Palisa charts. If all of these methods failed as they might in the case of faint stars on a D.M. chart, the filar was used, the wire set as nearly as possible on the star and the light flashed in and out to see if the position could be improved. Fortunately this was not often necessary as it was somewhat of a strain on the eyes.

The positions thus obtained were reduced to 1900 and given to seconds of time in right ascension and to tenths of minutes of arc in declination. After the positions were finally reduced, they were plotted and the drawings compared with those made at the telescope and again with the sky in order to detect possible errors.

No doubt some positions might have been obtained from volumes of the Astrographic Chart of the Heavens, but on the whole it took less time to observe the stars with the filar than to search for them in all the possible sources.

The most difficult part of the work and the one which has taken the longest time is the determination of the magnitudes of the comparison stars, and their reduction to a homogeneous system. For many reasons it seemed best to adopt the standard of the Harvard photometry, and hence it became necessary to find a method of connecting other methods with this. Fortunately, provisions for this already existed in the case of the Hagen charts, and tables for making the transformation can be found in volume 37 of the *Harvard Annals*. It is not necessary at this time to enter into any further discussion of these tables. It need only be stated that they contain the relation between the Harvard magnitude and the Hagen grade for many of the stars in the first three series of the Hagen

charts, but not for all. Vol. 57 of the *Annals* also contains comparison stars for many other long period variables. By means of the tables in these two volumes it was possible to determine the magnitudes of the comparison stars for practically all of the Hagen regions, with the exception of very faint stars, as in many cases the magnitudes assigned to them in the publications did not accord with those found by observation. It is therefore necessary to describe somewhat in detail, the method finally adopted for determining these faint magnitudes.

So far as is known to the writer the only photometric observations of very faint stars made with a large telescope are those made by Parkhurst with the forty-inch Yerkes telescope, and the magnitudes published in his tables are based on the Harvard Photometry as well as the Potsdam scale. Tracings of his maps were used in connection with the Hagen charts, particularly for the star V Delphini which was then in very good position for observation. It had previously been assumed that the theoretical limiting power of the twelve-inch was 14.2 mag. After observing V Delphini on several different evenings under exceptionally good conditions, it was found that 14.0 mag. star could be glimpsed frequently without much effort, while a 14.2 mag. could be seen only with the greatest difficulty. Therefore it was adopted as the limit of visibility. A study was made also of all the magnitudes below 12.8, in order to fix in the mind as far as possible the absolute brightness of stars of mag. 12.8, 13.0, 13.3, 13.5, and 13.8 and considerable confidence in the power to estimate these magnitudes directly was finally acquired. At the same time comparisons by the step method were also made, connecting the faint stars with the bright ones. It was found that these brought nearly the same results, and it is believed that the faint magnitudes thus determined will be found to be quite consistent throughout, and in accord with the Parkhurst-Harvard system. In making these estimates, particular care was taken by the observer to keep the eye protected. The right eye was used for making the estimate and then closed, while the left eye was used for making the record. A very marked difference in the darkness of the telescopic field resulted from this practice, owing to the decrease in the sensitiveness of the retina of the left eye. Fortunately this is not a permanent weakening, for in daylight equality is restored.

The magnitudes of the faint stars determined in this way were used to correct or to extend the tabular values given by Hagen or Harvard.

For variables which were not on the Hagen or Harvard lists, the magnitudes of the comparison stars were determined by the step method, using as a basis such stars in the neighborhood as could be found in the various volumes of the Harvard Photometry. The lower end of the scale was always found by estimating directly the magnitudes of the fainter stars.

It would have been quite impossible to make observations of the faint stars with the wedge photometer, as the field of view was not dark enough to show them easily.

The work of editing these observations has progressed towards its completion. The magnitudes of the comparison stars for nearly all the variables have been determined, the observations examined and the resulting magnitudes checked and plotted, and compared with other published observations as far as possible. There remain yet about twenty stars in the north for which the comparison stars must be observed.

In order to make these observations as useful as possible to other workers the introduction will contain a very complete statement of the methods of reduction with ample illustrations. For each variable will be given the common name, such as R Herculis, the Harvard number, the Hagen series, and the position for 1855. Following this heading there will be a brief but very explicit statement describing the designations of the comparison stars, and the method of obtaining their positions and magnitudes. When the positions of any of these stars have been observed at the Vassar College Observatory, they will be published for the epoch 1900. The observations will follow, in which will be given the calendar date, the Julian Day with the hour and minute for short period variables, the instrument used, the observer, the original comparison, the resulting magnitude and remarks. Following each table of observations will be a place for general remarks and conclusions drawn from a study of the curve of the star. At the end will be general tables and a summary of the results.

It should be stated that many of these observations have already been published, either in the Harvard Annals or in the *Ast. Nach.* Observations of maxima and minima have frequent appeared in the *Ast. Jour.* and *Ast. Nach.* However, it was thought that since many of them have not appeared, the projected publication should include them all, reduced in this way to a homogeneous system. This seems particularly desirable since hereafter, the chief activity of the Observatory will be turned in another direction, as we have engaged to take

a share in the study of Kapteyn's Selected Areas, and are provided with a stereo-comparator for that purpose. We shall not, however, entirely give up work on variable stars, though we shall not have time to carry it on as extensively as in the past.

AN AMATEUR'S OBSERVATORY.

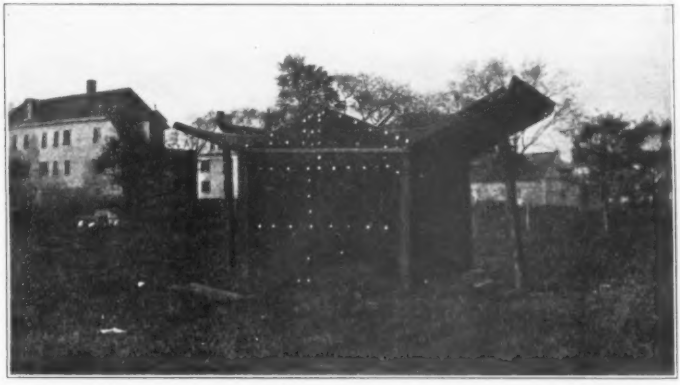
ALLAN B. BURBECK

Having been an interested reader of everything pertaining to astronomy contained in the libraries to which I have had access, and for many years hoping that some day I could own a telescope, that I might see with my own eyes some of the beautiful and wonderful objects of the heavens, it is my desire, now that my fondest anticipation has been realized, to tell the readers of POPULAR ASTRONOMY of the manner in which my observatory was erected during my leisure hours, and of the splendid equatorial mounting of which I am the proud possessor. I hope that other amateurs may receive some suggestions from this article.

MR. BURBECK'S OBSERVATORY.

The land in the rear of my home consists of about one half an acre, bounded on two sides by small trees, and the horizon is nearly in view upon the other two sides. In the center of this field I set four cedar posts three feet into the ground and

six feet above, in a square eight by eight. These were connected with sticks, two by three inches, for a frame. After boarding the sides with matched pine, and leaving a door on the west side and a window on the south, my first real problem was how to arrange the roofs, so that they might be opened and adjusted separately with the least possible effort and in the most practical manner. I decided to attach them on hinges at the eaves, so that with the aid of a small block and tackle each could be raised and swung over to a post upon which it should rest when

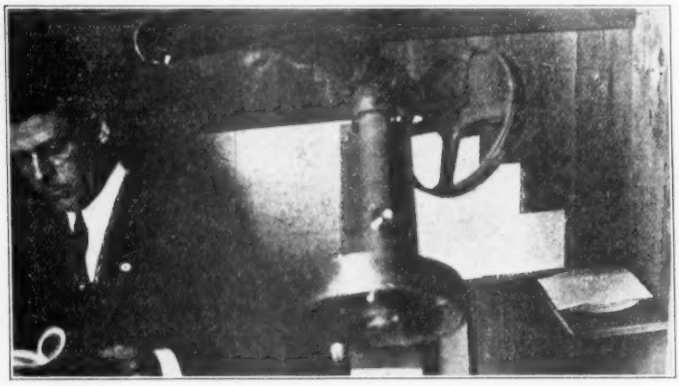


MR. BURBECK'S OBSERVATORY WITH THE ROOF OPEN

open. On the north roof a piece of galvanized iron was nailed and bent over to the slant of the south roof, answering for a saddle board to keep the weather from coming through the joint where they came together. The ridge pole was placed in two pockets so it could be taken down when the roofs were opened thus allowing a free sweep over the entire celestial vault above. The inside of the building was lined with matched pine and a coating of tar paper was used on the outside and roofs. With a coat of pain on the outside trimmings and a maple floor the building was complete. A few shelves inside made a good place to take care of the star maps, the books and the various memoranda which accumulate from time to time. An astral lantern made from the suggestions of Dr. Gray of California in a recent issue of POPULAR ASTRONOMY is a very valuable and necessary addition to the inside. The space between the two walls was utilized so that it was built in the form of a cupboard with a glass door.

Joining the association for observing variable stars, after some very pleasant correspondence with Mr. W. T. Olcott of

Norwich, Connecticut, its secretary, I made my first observation, with my 3″ Bardou telescope mounted upon a simple tripod. This is a very fascinating pleasure—the turning of the telescope at intervals to these silent twinkling enigmas and watching them growing brighter or more dim, as the case may be, and the comparing of your estimates with the reports of others in the same work as noted monthly in POPULAR ASTRONOMY. I found at first some difficulty in locating the field in which the variable was situated—in some instances I would search and sweep until my patience was nigh exhausted before it was found. It was obvious that an equatorial mounting for the telescope



THE POLAR AXIS OF MR. BURBECK'S TELESCOPE.

would aid a great deal but the probable cost would make it prohibitive in my case. Again, Mr. Olcott kindly assisted; through him, I came into correspondence with Mr. W. L. Barnes, of Charlestown, Indiana, and the result was a beautiful equatorial at an extraordinarily low price. It is mounted upon an oak post, set into the ground five feet and standing above the floor five feet, not touching the floor at any point, to prevent wind vibrations of the building being communicated to the post and telescope. The top of the post is sawed off at an angle of 42°, corresponding to the latitude of its terrestrial location. The equatorial is very well put together, its polar axis and right ascension axis being of steel, turning in iron tubes. Upon each axis is a wheel, the rim of which holds a brass circle, one showing the degrees and minutes of declination, the other hours and minutes of right ascension. There is also a time circle of brass very cleverly adjusted to the right ascension circle. Several

small bolts are so located as to enable one to adjust the polar axis perfectly true to the north pole of the heavens. The entire work was done by Mr. Barnes alone, and his ingenuity and accuracy should be a great pride to himself. With the explicit instructions given by him it was easily mounted and adjusted. He made it so well and so simple to manipulate that its service doubles the pleasure of variable star observing.

NOTES ON THE PERIODS OF 15 ECLIPSING VARIABLES.

HARLOW SHAPLEY.

At the request of the editor I submit below a few notes relative to the elements of light variation of eclipsing variable stars. The results have been obtained in some cases from a discussion of my own observations made at Princeton, and in others from a study of observations made and published elsewhere.

For many eclipsing variables the published initial epochs of minimum do not refer to the middle or deepest phase of the eclipse, but refer instead to some point near that time. An unfortunate result of this is that attempts are made occasionally to correct a star's period because of a discrepancy between the ephemeris (based on the erroneous initial epoch) and an observed time of exact mid-eclipse. Wherever I have found the reference point of an initial epoch differing considerably from the true zero phase, I have corrected it in the table below. For those stars not mentioned in the notes which follow the table no other correction is made to the light elements than this adjustment of the initial minimum. There is a possibility of confusing the primary and secondary minima of U Ophiuchi, RZ Centauri and SZ Centauri.

REVISED PERIODS AND EPOCHS OF MINIMA.

	Star	Initial Epoch of Minimum (Greenwich Hel. M.T.)	Period d
1.	U Coronae	J. D. 2404147.3344	3.4522269
2.	RR Draconis	2417026.682	2.831073
3.	Y Piscium	2410002.844	3.76582
4.	W Crucis	2410150	198.5
5.	U Ophiuchi (Primary Min.)	2418026.703	1.6773476
6.	Z Herculis	2413086.358	3.992754
7.	RZ Centauri (Primary Min.)	2410000.155	1.87592
8.	U Cephei	2407890.2992	2.492884
9.	δ Librae	2403265.3712	2.3273473
10.	S Cancri	2403210.6053	9.484549

	Star	Initial Epoch of Minimum (Greenwich Hel. M.T.)	Period
			d
11.	UZ Cygni	2410015.11	31.30400
12.	RX Draconis	2417502.411	1.893175
13.	SS Carinae	2410001.395	3.30080
14.	SZ Centauri (Primary Min.)	2410001.789	4.10796
15.	RS Sagittarii	2415023.0930	2.415702

NOTES TO THE TABLE.

1. U Coronae. In the original determination of the elements, Wendell chose as initial epoch, not the deepest phase of minimum, but a point near the end of the eclipse $2^h\ 37^m$ later. The correction to the ephemeris of $-2^h\ 47^m$ found by Lehnert (*A.N.* 4596) on March 30, 1912, does not indicate, therefore, any perceptible correction to the period. I give the period here as determined by Wendell, but have corrected the epoch.

2. RR Draconis. From recent photometric observations in two minima corrections have been found for both period and initial epoch.

3. Y Piscium. The elements have been investigated on the basis of photometric observations of one minimum and photographic observations of four. The period originally determined by Miss Leavitt is unchanged; the epoch of minimum has been slightly altered.

4. W Crucis. The period was recently determined by Miss Leavitt, and Professor Russell suggests a correction to the minimum phase of one day. (*Ap. J.* 36, 147).

5. U Ophiuchi. The secondary minimum, at which the loss of light is nearly equal to that of the primary, occurs ten minutes less than one-half a period after the principal eclipse. Heretofore the two minima have not been distinguished from each other.

7. RZ Centauri. The depth of the primary minimum is $0^m.47$. and of the secondary, which follows by exactly one-half period, is $0^m.35$. (*A. N.* 4589).

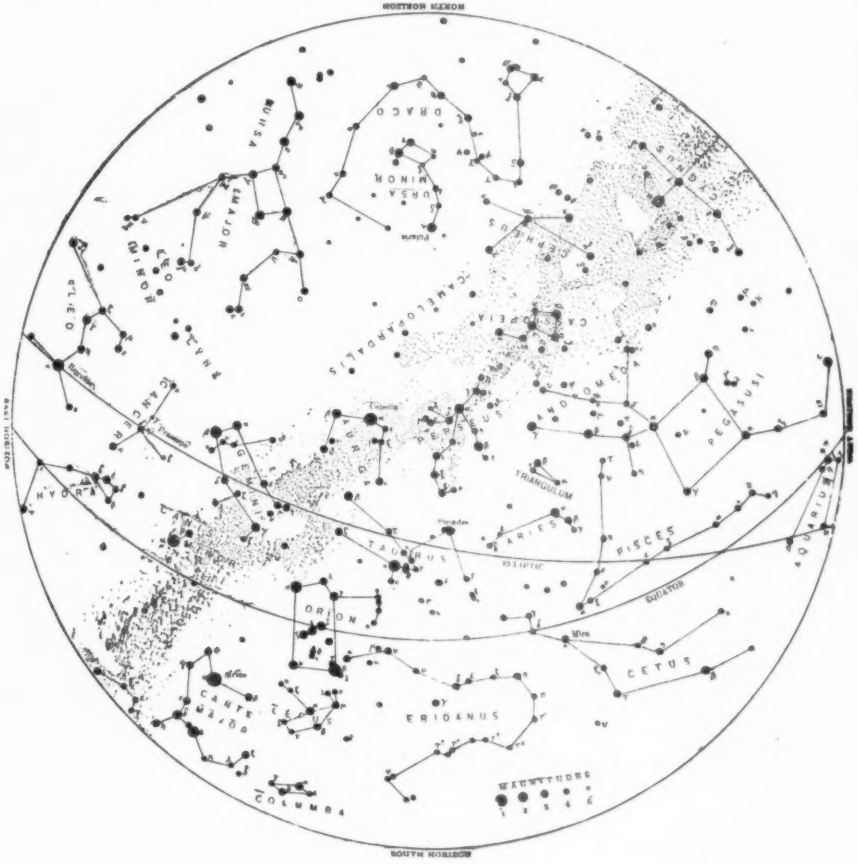
12. RX Draconis. The elements in the table are those given by Haynes in Laws Observatory Bulletin No. 18. I observed minima on the nights of Mar. 16, Apr. 10, and Apr. 25 of this year. All of them are represented by the above formula within the error of the estimated times of mid-eclipse.

14. SZ Centauri. The secondary minimum follows the primary by one-half the period. The latter is less than a tenth of a magnitude deeper.

Princeton University Observatory.
November 4, 1912.

PLANET NOTES FOR JANUARY, 1913.

The sun will move northward about six degrees during this month reaching the declination 17° 28′ at the end of the month. Its path eastward lies through Sagittarius into Capricornus.



THE CONSTELLATIONS AT 9:00 P. M. JANUARY 1, 1913.

The phases of the moon for this month are as follows:

New Moon	Jan. 7	at	4 A. M.	C.S.T.
First Quarter	15	,,	10 A. M.	,,
Full Moon	22	,,	10 A. M.	,,
Last Quarter	29	,,	1 A. M.	,,

Mercury in the early part of the month will be visible in the east just before sunrise, It will move toward the sun and soon become lost in the rays of the sun.

Venus will be approximately three hours east and several degrees north of the sun throughout the month. It will be very high in the sky in the evening and will be very brilliant.

Mars will appear in the east a little before sunrise. It will rise earlier each succeeding night but at no time during the month will it be well situated for observation.

Jupiter at the end of the month will again be visible in the early morning. It will be very low in the east at sunrise and will not be well situated for observation. Near the middle of the month Jupiter and Mars will be very close to each other, both being quite for south.

Saturn will be the most interesting planet during the month because of its favorable position for observing. It will cross the meridian at 9 p. m. on January 1, and about four minutes earlier each succeeding night.

Uranus will be in conjunction with the sun on January 23. It will therefore not be visible during the month.

Neptune will be in opposition to the sun on January 14. On this date it will cross the meridian at midnight. It will be favorably situated and may be found in the constellation Gemini.

Occultations visible at Washington.

Date 1918	Star's Name	Magnitude	IMMERSION. Washington M.T. h m	IMMERSION. Angle f'm N. °	EMERSION. Washington M.T. h m	EMERSION. Angle f'm N °	Duration h m
Jan. 2	42 Librae	5.0	16 33	74	17 21	343	0 48
19	406 B Tauri	5.6	14 37	99	15 34	276	0 57
20	49 Aurigae	5.1	4 31	6	4 42	342	0 11
21	*c* Geminorum	5.5	5 0	91	5 53	274	0 53
21	4 Cancri	6.2	13 11	88	14 15	318	1 4
23	34 Leonis	6.4	17 19	174	17 59	254	0 40
24	χ Leonis	4.7	15 25	118	16 34	321	1 9
25	β Virginis	3.8	10 35	101	11 32	324	0 57
26	319 B Virginis	6.3	14 14	125	15 28	316	1 14

Saturn's Satellites.

CENTRAL STANDARD TIME.

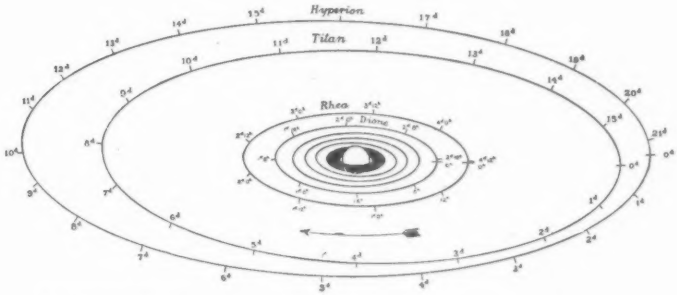
E = eastern elongation; W = western elongation.
I = inferior conjunction; S = superior conjunction

I. Mimas. Period $0^d\ 22^h.6$.

	h		h		h		h
Jan. 2	13.7 E	Jan. 8	5.4 E	Jan. 15	7.0 W	Jan. 23	7.3 E
3	12.3 E	10	13.9 W	16	5.6 W	24	5.9 E
4	10.9 E	11	12.5 W	19	12.8 E	28	11.6 W
5	9.5 E	12	11.1 W	20	11.4 E	29	10.3 W
6	8.1 E	13	9.8 W	21	10.1 E	30	8.9 W
7	6.8 E	14	8.4 W	22	8.7 E	31	7.5 W

II. Enceladus. Period $1^d\ 8^h.9$.

Jan. 2	4.3 E	Jan. 10	9.6 E	Jan. 18	14.9 E	Jan. 25	11.4 E
3	13.2 E	11	18.5 E	19	23.8 E	26	20.3 E
4	22.1 E	13	3.4 E	21	8.7 E	28	5.2 E
6	7.0 E	14	12.3 E	22	17.6 E	29	14.0 E
7	15.9 E	15	21.1 E	24	2.5 E	30	22.9 E
9	0.7 E	17	6.0 E				



APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, at date of opposition, November 23, 1912, as seen in an inverting telescope.

III. Tethys. Period $1^d\ 21^h.3$.

Jan. 2	7.5 E	Jan. 9	20.5 E	Jan. 17	9.7 E	Jan. 24	22.9 E
4	4.6 E	11	17.8 E	19	7.0 E	26	20.2 E
6	1.9 E	13	15.1 E	21	4.3 E	28	17.5 E
7	23.2 E	15	12.4 E	23	1.6 E	30	14.8 E

IV. Dione. Period $2^d\ 17^h.7$.

Jan. 2	17.6 E	Jan. 10	22.6 E	Jan. 19	3.6 E	Jan. 27	8.7 E
5	11.2 E	13	16.3 E	21	21.3 E	30	2.4 E
8	4.9 E	16	9.9 E	24	15.0 E		

V. Rhea. Period $4^d\ 12^h.5$.

Jan. 4	18.2 E	Jan. 13	19.0 E	Jan. 22	19.8 E	Jan. 31	20.7 E
9	6.6 E	18	7.4 E	27	8.2 E		

VI. Titan. Period $15^d\ 23^h.3$.

Jan. 2	1.4 I	Jan. 9	18.7 S	Jan. 17	23.5 I	Jan. 25	17.1 S
5	21.2 W	13	22.0 E	21	19.5 W	29	22.5 E

VII. Hyperion. Period $21^d\ 7^h.6$.

Jan.	^{d} 5.6 W 11.6 S	Jan.	^{d} 16.7 E	Jan.	^{d} 21.4 I	Jan.	^{d} 26.9 W

VIII. Japetus. Period $79^d\ 22^h.1$.

Jan. 8.9 S Jan. 29.1 E

IX. Phoebe. Period $580^d\ 2^h.9$.

	α Ph.—α Sat.			δ Ph.—δ Sat.			α Ph.—α Sat.			δ Ph.—δ Sat.	
	m	s		′	″		m	s		′	″
Jan.	1 2	19.1		+11	46	Jan. 17	2	3.7		10	52
	5 2	15.5		11	35	21	1	59.3		10	35
	9 2	11.7		11	22	25	1	54.7		10	16
	13 2	7.8		11	8	29	+1	50.0		+ 9	56

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on Nov. 1, 1912.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900.	Decl. 1900.	Magn.
	h m	° ′			h m	° ′	
X Androm.	0 10.8	+46 27	14.1	V Can. Min.	7 1.5	+ 9 2	9.4
T Androm.	17.2	+26 26	9.2*d*	R Can. Min.	3.2	+10 11	8.1
T Cassiop.	17.8	+55 14	8.7*d*	RR Monoc.	12.4	+ 1 17	<13.0
R Androm.	18.8	+38 1	<12.0	S Can. Min.	27.3	+ 8 32	<11.0
S Ceti	19.0	− 9 53	<11.0	U Can. Min.	35.9	+ 8 37	8.3
Y Cephei	31.3	+79 48	<13.0	R Cancri	8 11.0	+12 2	8.6*d*
U Cassiop.	40 8	+47 43	8.9*d*	Y Draconis	9 31.1	+78 18	9.2 *i*
RW Androm.	41.9	+32 8	<11.0	R Leonis	42.2	+11 54	9.9
V Androm.	44.6	+35 6	<12.0	R Urs. Maj.	10 37.6	+69 18	8.8*d*
RR Androm.	45.9	+33 50	<12.0	T Urs. Maj.	12 31.8	+60 2	8.8 *i*
RV Cassiop.	47.1	+46 53	<14.0	RS Urs. Maj.	34.4	+59 2	<13.0
W Cassiop.	49.0	+58 1	11.3 *i*	S Urs. Maj.	39.6	+61 38	10.3 *i*
U Androm.	1 9.8	+40 11	<13.0	T Urs. Min.	13 32.6	+73 56	13.1
S Piscium	12.4	+ 8 24	10.5*d*	R Can. Ven.	44.6	+40 2	10.6
S Cassiop.	12.3	+72 5	<12.0	S Boötis	14 19.5	+54 16	8.4
RZ Persei	23.6	+50 20	11.2*d*	V Boötis	25.7	+39 18	7.7
R Piscium	25.5	+ 2 22	12.5	R Camelop.	25.1	+84 17	9.7
Y Androm.	33.7	+38 50	10.5*d*	R Boötis	32.8	+27 10	7.2
X Cassiop.	49.8	+58 46	10.1	S Cor. Bor.	15 17.3	+31 44	9.9
R Arietis	2 10.4	+24 35	11.2*d*	RU Librae	27.7	−14 59	<11.0
Z Cephei	12.8	+81 13	<13.0	S Urs. Min.	33.4	+78 58	8.1
o Ceti	14.3	− 3 26	8.7	R Cor. Bor.	44.4	+28 28	5.9
S Persei	15.7	+58 8	9.5	W Cor. Bor.	16 11.8	+38 3	11.3*d*
R Ceti	20.9	− 0 38	8.0	U Herculis	21.4	+19 7	11.3 *i*
RR Persei	21.7	+50 49	<13.0	W Herculis	31.7	+37 32	<12.0
U Ceti	28.9	−13 35	10.2*d*	R Urs. Min.	31.3	+72 28	9.6
RR Cephei	29.4	+80 42	<12 0	R Draconis	32.4	+66 58	8.7 *i*
R Trianguli	31.0	+33 50	9.8	S Herculis	47.4	+15 7	8.5
W Persei	43.2	+56 34	9.2	RV Herculis	56.8	+31 22	9 5
U Arietis	3 5.5	+14 25	<12.0	R Ophiuchi	17 2.0	−15 58	<10.0
X Ceti	14.3	− 1 26	<12.0	T Draconis	54.8	+58 14	<11.0
Y Persei	20.9	+43 50	8.3	V Draconis	56.3	+54 53	9.6
R Persei	23.7	+35 20	9.9	T Herculis	18 5.3	+31 0	9.1
T Eridani	51.0	−24 20	9.1	W Draconis	5.4	+65 56	12.1
W Tauri	4 22.2	+15 49	10.7	X Draconis	6.8	+66 8	11.7
T Camelop.	30.4	+65 57	13.6	W Lyrae	11.5	+36 38	9 1
— Tauri	32.8	+ 8 9	<12.0	SV Draconis	31 2	+49 18	13.1*d*
X Camelop.	32.6	+74 56	9.8*d*	RY Lyrae	41.2	+34 34	13.6*d*
R Orionis	53.6	+ 7 59	<12.0	Z Lyrae	56.0	+34 49	<13.0
R Leporis	55.0	−14 57	8.6	V Lyrae	19 5 2	+29 30	<13.0
V Orionis	5 0.8	+ 3 58	<12.0	S Lyrae	9.1	+25 50	11.0*d*
R Aurigae	9.2	+53 28	8.1	U Draconis	9.9	+67 7	12.1
S Aurigae	20.5	+34 4	9.2	W Aquilae	10.0	− 7 13	12.8
S Camelop.	30.2	+68 45	8.7	U Lyrae	16.6	+37 42	10.0
U Aurigae	35.6	+31 59	<12.0	R Cygni	34.1	+49 58	13.6
Z Tauri	46.7	+15 46	<12.0	RT Cygni	40.8	+48 32	9.1
U Orionis	49.9	+20 10	10.7	TU Cygni	43.3	+43 49	10 2
V Camelop.	49.4	+74 30	<12.0	χ Cygni	46.7	+32 40	5.8
Z Aurigae	53.6	+53 18	9.5 *i*	Z Cygni	58.6	+49 46	<11.0
U Lyncis	6 31.8	+59 57	<13.0	SV Cygni	20 6.5	+47 35	9.3*d*
S Lyncis	35.9	+58 0	9.4	S Aquilae	7.0	+15 19	10.0
Nova Gem. 2	45.5	+32 17	8.0	RW Aquilae	7.3	+15 46	8.9
R Lyncis	53.0	+55 28	11.7 *i*	R Sagittae	9.5	+16 25	9.2

Approximate Magnitudes of Variable Stars on Nov. 1, 1912.—Con.

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900	Decl. 1900	Magn.
	h m	° ′			h m	° ′	
RS Cygni	20 9.8	+38 28	7.4	S Cephei	21 36.5	+78 10	<11.0
R Delphini	10.1	+ 8 47	<11.0	RV Cygni	39.1	+37 34	7.9
RT Capricorni	11.3	−21 38	6.3	V Pegasi	56.0	+ 5 38	8.3
SX Cygni	11.6	+30 46	<13.0	T Pegasi	22 4.0	+12 3	<13.0
V Sagittae	15.8	+20 47	10.4	Y Pegasi	6.8	+13 52	<12.0
U Cygni	16.5	+47 35	10.9	S Lacertae	24.6	+39 48	12.9
ST Cygni	29.9	+54 38	12.1 *i*	R Lacertae	38.8	+41 51	12.4
TV Cygni	30.0	+46 13	10.0	S Aquarii	51.8	−20 53	9.1
S Delphini	38.5	+16 44	11.1	RW Pegasi	59.2	+14 46	14.0
V Cygni	38.1	+47 47	9.5	R Pegasi	23 1.6	+10 0	7.8
T Delphini	40.7	+16 2	<13.0	V Cassiop.	7.4	+59 8	9.6*d*
T Aquarii	44.7	− 5 31	8.9	ST Androm.	33.8	+35 13	9.1
RZ Cygni	48.5	+46 59	11.1 *i*	R Aquarii	38.6	−15 50	9.2
RS Capric.	21 1.7	−16 49	8.0	RR Cassiop	50.7	+53 8	<14.0
TW Cygni	1.8	+29 0	9.9	V Ceti	52.8	− 9 31	<13.0
X Cephei	3.6	+82 40	<13.0	R Cassiop.	53.3	+50 50	11.4
R Equulei	8.4	+12 23	12.4 *i*	Y Cassiop.	58.2	+55 7	9.8
T Cephei	8.2	+68 5	6.8*d*	SV Androm.	59.2	+39 33	11.8
W Cygni	32.2	+44 56	5.7 *i*				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:— T. C. H Bouton, A. P. C Craig, E. L. Forsyth, C. E. Furness, Edward Gray, F. E. Hathorn, S. E. Hunter, J. B. Lacchini, F. C. Leonard, C. Y. McAteer, Wm. T. Olcott, H. M. Swartz, D. Todd, H. W. Vrooman, J. M. White, I. E. Woods, and A. S. Young.

Many observations were received of T Persei, of which there is no good evidence of variability.

Minima of Variable Stars of the Algol Type.

[Calculated by Myrtle L. Richmond, E. R. Peterson and S. N. Stearns at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h, etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in **January** 1913
	h m	° ′		d h	d h; d h; d h; d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.6	18 8
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	7 2; 14 13; 21 23; 29 10
U Cephei	0 53.4	+81 20	7.1— 9.2	2 11.8	3 9; 10 20; 18 8; 25 19
Z Persei	2 33.7	+41 46	9.4—12.	3 01.4	1 3; 7 6; 25 14; 31 17
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	6 18; 13 15; 20 11; 27 8
RZ Cassiop.	39.9	+69 13	6.4— 7.8	1 04.7	9 0; 16 5; 23 9; 30 13
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	6 17; 14 16; 22 14; 30 13
RX Cephei	2 58.8	+67 11	8.6— 9.1	32 07.6	5 6
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	1 21; 7 14; 19 1; 30 13
RT Persei	16.7	+46 12	9. —11.	0 20.4	4 0; 10 19; 24 10; 31 5
λ Tauri	55.1	+12 12	3.4— 4.5	3 22.9	7 9; 15 6; 23 4; 31 2
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2 17; 8 6; 16 13; 24 20
RV Persei	4 04.2	+33 59	10.6—12.8	1 23.4	2 5; 8 3; 19 23; 31 20
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	25 17
RS Cephei	4 48.6	+80 06	9.5—12.2	12 10.1	5 12; 17 23; 30 9
RY Aurigæ	5 11.5	+38 13	10.7—11.7	2 17.5	1 13; 7 0; 17 22; 28 20
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	6 12; 12 13; 24 14; 30 14
SV Gemini	54.6	+24 28	9.8—<11	4 00.2	8 10; 16 10; 24 10
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	4 16; 10 10; 21 21; 27 14
U Columbæ	6 11.2	−33 03	9.4—10.2	2 19.2	4 15; 10 5; 21 10; 27 0

Minima of Variable Stars of the Algol Type.—Continued.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in **January** 1913 d h d h d h d h
SX Gemin.	22.	+20 37	10.8—11.5	1 08 8	1 10; 6 21; 17 20; 28 18
RW Monoc.	29.3	+ 8 54	9.0—10 8	1 21.7	1 17; 9 8; 16 23; 24 14
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	8 20; 21 1
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	1 19; 7 4; 19 17; 26 21
R Canis Maj.	7 14.9	—16 12	5.9— 6.7	1 03.3	6 16; 12 8; 23 16; 29 9
RY Gemin.	7 21.7	+15 52	8.9—<10	9 07.2	5 3; 14 10; 23 17
Y Camelop	27.6	+76 17	9.5—12.	3 07.3	9 5; 15 20; 22 10; 29 1
RR Puppis	43.5	−41 08	9.5—	6 10.3	5 18; 12 4; 25 0; 31 11
V Puppis	55.4	−48 58	4. — 5.	1 10.9	2 2; 9 8; 23 21; 31 4
X Carinæ	8 29.1	−58 53	7.8— 8.9	0 13.0	4 21; 11 7; 22 3; 27 13
S Cancri	8 38.2	+19 24	8. —10.	9 11.6	2 15; 12 2; 21 14; 31 1
S Velorum	9 29.5	−44 46	7.8— 9.5	5 22.4	5 23; 11 21; 23 18; 29 16
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6, 9; 14 20; 23 6; 31 16
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	9 22; 19 5; 28 11
SS Carinæ	10 54.2	−61 23	12.2—12.8	3 07.2	3 14; 10 5; 23 10; 30 0
RW Urs. Maj.	11 35.4	+52 34	9.3—10.3	7 07.9	3 12; 10 20; 18 3; 25 11
Z Draconis	11 40.6	+72 49	9.5—12.5	1 08.6	6 13; 13 8; 20 3; 26 22
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	8 9; 15 20; 23 6; 30 17
δ Libræ	14 55.6	— 8 07	5. — 6.7	2 07.9	5 6; 12 6; 19 5; 26 5
U Coronæ	15 14.1	+32 01	7.8— 9.0	3 10.9	4 3; 11 1; 24 20; 31 18
TW Draconis	15 32.4	+64 14	7.0— 8.9	2 19.4	5 16; 14 2; 22 13; 30 23
SW Ophiuchi	16 11.1	— 6 44	9.2—10.	2 10.7	2 18; 10 2; 17 11; 24 19
SX Ophiuchi	16 12.6	— 6 25	10.5—11.2	2 01.5	1 9; 13 18; 22 0; 30 6
R Aræ	16 31.1	−56 48	6.7— 8.	4 10.2	1 0; 9 21; 18 17; 27 14
TT Herculis	16 49.9	+17 00	8.9— 9.5	20 18.1	4 1; 15 2; 24 19
TU Herculis	17 09.8	+30 50	9.5—12.	2 06.4	6 13; 13 9; 20 4; 26 23
U Ophiuchi	11.5	+ 1 19	6. — 6.7	0 20.1	4 20; 13 5; 21 15; 30 0
SZ Herculis	36.0	+33 01	9 5—10.3	0 19.6	3 11; 11 15; 19 19; 28 0
Z Herculis	17 53.6	+15 09	6.7— 8.0	3 23.8	2 5; 10 5; 18 5; 26 4
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	6 3; 11 7; 21 15; 31 23
RS Sagittarii	11.0	−34 08	6.7— 7.8	2 10.0	6 18; 14 0; 21 6; 28 12
V Serpentis	11.1	−15 34	9.5—	3 10.9	1 3; 8 1; 21 20; 28 18
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	5 5; 10 17; 21 18; 27 6
RX Herculis 18	26.0	+12 32	7.8— 8.0	0 21.3	9 18; 18 16; 27 13
SX Sagittarii	39.7	−30 36	8.6— 9.4	2 01.8	3 22; 10 3; 22 14; 28 20
RR Draconis	40.8	+62 34	9.3—13.	2 19.9	2 0; 10 12; 19 0; 27 11
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	7 16; 14 07; 20 23; 27 14
U Scuti 18	48.9	−12 44	9.0— 9.8	0 22.9	4 8; 9 3; 18 16; 28 5
RX Draconis 19	01.1	+58 35	9.3—10.2	1 21.5	7 5; 16 16; 26 3
RV Lyræ	12.5	+32 15	11. —13.	3 14.4	7 11; 14 16; 21 21; 29 1
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	5 14; 14 13; 23 12
U Sagittæ	14.4	+19 26	6.7— 9.0	3 09.1	6 1; 12 19; 19 14; 26 8
Z Vulpec.	17.5	+25 23	7.3— 8 5	2 10.9	7 10; 14 19; 22 4; 29 13
TT Lyræ	24.3	+41 30	9.0<11.0	5 05.8	1 19; 7 1; 17 12; 28 0
SY Cygni 19	42.7	+32 28	10. —12.	6 00.2	6 4; 12 4; 24 4; 30 4
WW Cygni 20	00.6	+41 18	9.5—12.5	3 07.6	6 20; 13 11; 20 2; 26 17
SW Cygni	03.8	+46 01	9. —12.	4 13.8	3 13; 12 16; 21 20; 30 23
VW Cygni	11.4	+34 12	9.5—11.5	8 10.3	3 10; 11 21; 20 7; 28 17
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	4 14; 11 9; 24 23; 31 18
UW Cygni	19.6	+42 55	10.5—13.	3 10.8	1 12; 8 10; 22 5; 29 3
W Delphini	33.1	+17 56	9.5—11.5	4 19.4	1 15; 11 6; 20 20; 30 11
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	6 18; 15 23; 25 4
Y Cygni	48.1	+34 17	7. — 8.	1 12.0	3 7; 10 18; 18 6; 25 18
RR Vulpec. 20	50.5	+27 32	9.6—11.0	5 01.2	4 3; 9 4; 19 7; 29 9
VV Cygni 21	02.3	+45 23	11. —14.	1 11.4	6 4; 13 13; 20 23; 28 8
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	6 20; 14 15; 22 10; 30 4
UZ Cygni	55.2	+43 52	9. —11.5	31 07.3	13 22
RT Lacertæ 21	57.4	+43 24	9.1—10.5	5 01.7	3 22; 8 24; 19 3; 29 7
RW Lacertae 22	40.6	+49 08	10.2—11.2	5 04.4	4 3; 9 8; 19 16; 30 1
TT Androm 23	08.7	+45 36	10.5—11.3	2 18.3	1 20; 10 3; 18 10; 26 17
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	7 3; 14 16; 22 5; 29 18
TW Androm. 23	58.2	+32 17	8.6—11.5	6 02.9	7 5; 15 10; 23 16; 31 22

Maxima of Variable Stars of Short Period not of the Algol Type.

[Calculated by May E. Abbott, Hazel H. Barnard, Helen A. Orr, and Myrtle L. Richmond at Goodsell Observatory]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h etc. An * following the name of a star signifies that for that star times of minima instead of maxima are given.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in January 1913.
	h m	° ′		d h	d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9·4	36 13.7	8 20
SY Cassiop.	9.8	+57 52	9 3— 9.9	4 1.7	7 16; 15 19; 23 23
RT Sculptor.*	0 31.5	−26 13	9.6—10.5	0 12.3	7 12; 15 4; 22 20; 30 12
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	8 14; 16 8; 24 2; 31 20
RW Cassiop.	1 30.7	+57 15	8.6— 9.4	14 19 2	2 22; 17 17
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	5 17; 13 15; 21 14; 29 13
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	2 8; 10 3; 17 22; 25 17
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	5 2; 12 9; 19 16; 26 23
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	9 0; 25 0
SX Persei	4 10.2	+41 29	10.3—11.0	4 07.1	8 2; 16 16; 25 6
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	10 4; 26 7
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	12 11; 24 2
TT Aurigæ*	02.8	+39 27	7.8— 8.7	0 16.0	4 6; 10 22; 17 14; 30 22
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	7 14; 15 5; 22 21; 30 13
SY Aurigæ	5 05.5	+42 42	9.0— 9.7	10 03.3	1 14; 11 17; 21 20; 31 23
Y Aurigæ	21.5	+42 21	9. —	3 20.6	5 14; 13 7; 21 1; 28 18
SV Tauri*	45.8	+28 05	9.4—11.0	2 04.0	7 11; 13 23; 20 11; 26 23
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 14; 10 3; 21 4; 26 17
RS Orionis	6 16.5	+14 43	7.8— 8.5	7 13 4	2 5; 9 18; 17 8; 24 21
T Monoc.	19.8	+ 7 08	6. — 8.	27 00.3	22 5
RZ Camelop.	23.7	+67 06	11.0—12.8	0 11.5	2 9; 9 14; 24 0; 31 5
W Gemin.	29.2	+15 24	6 8— 7.6	7 22.0	5 7; 13 5; 21 3; 29 1
ζ Gemin.	6 58.2	+20 43	3.7— 4.5	10 03.7	11 1; 21 5; 31 8
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	12 5
RR Gemin.	7 15.2	+31 04	9.7—10.6	0 09.5	3 3; 11 1; 19 0; 26 23
V Carinæ	8 26.7	−59 47	7.2— 8.0	6 16.7	5 15; 12 7; 19 0; 25 17
T Velorum	8 34.4	−47 01	7.5— 8.5	4 15.3	5 8; 14 14; 23 21
W Carinæ	9 19.2	−55 32	7.5— 8.5	4 08.9	4 19; 13 13; 21 7; 31 1
S Antliæ*	27.9	−28 11	6.7— 7.8	0 07.8	4 21; 11 9; 24 8; 30 19
W Ursæ Maj.	9 36.7	+56 24	8.	0 04.0	4 13; 11 5; 24 13; 31 6
RR Leonis	10 02 1	+24 03	9.1—10.0	0 10.9	3 12; 10 7; 23 21; 30 15
ST Ursæ Maj.*	11 22.4	+45 44	6.7— 7.2	8 19.2	1 0; 9 19; 18 14; 27 10
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5 2; 11 16; 24 21; 31 12
S Muscae	12 07.4	−69 36	6.5— 7.3	9 15.8	2 18; 12 10; 22 2; 31 18
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 10; 10 10; 18 9; 25 8
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	6 12; 13 6; 20 0; 26 17
R Crucis	18.1	−61 04	6.8— 8.0	5 19.8	6 15; 12 11; 24 3; 29 23
S Crucis	48.4	−57 53	6.6— 7.8	4 16 6	5 2; 9 19; 19 4; 28 13
RZ Centauri	12 55.6	−64 05	8.5— 8.9	0 22 5	5 17; 13 5; 20 17; 28 5
W Virginis	13 20.9	− 2 52	9.0—10.0	17 06.5	4 3; 21 9
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	3 3; 10 3; 24 4; 31 5
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	9 3; 17 5; 25 10
V Centauri	25.4	−56 27	6.7— 7.6	5 11.9	4 7; 9 19; 15 7; 26 6
RS Bootis	29.3	+32 11	8.9—10.	0 09.1	7 9; 14 23; 22 12; 30 1
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	2 19; 10 5; 17 15; 25 1
RTriang. Austr	15 10.8	−66 08	6.7— 7.7	3 09.3	5 13; 12 7; 19 2; 26 21
STriang. Austr	15 52.2	−63 29	6.5— 7.5	6 07.8	4 1; 10 9; 16 17; 29 8
S Normæ	16 10.6	−57 39	6.5— 7.4	9 18.1	1 4; 10 22; 20 16; 30 10
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	4 14; 13 10; 22 7; 31 3

Maxima of Variable Stars of Short Period not of the Algol Type

Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of maxima in January 1913.
	h m	° ′		d h	d h d h d h d h
RV Scorpii	16 51.8	−33 27	6.8− 7.6	6 01.5	4 18; 10 19; 16 21; 22 22
u Herculis*	17 13.6	+33 12	5.1− 5.6	2 01 2	9 0; 15 4; 21 8; 27 11
RV Ophiuchi*	17 29.8	+ 7 19	9.−< 11	3 16.5	7 18; 15 3; 22 12; 29 21
X Sagittarii	41.3	−27 48	4.0− 6.0	7 00.3	5 23; 12 23; 19 23; 27 0
Y Ophiuchi	47.3	− 6 07	6.2− 7.0	17 02.9	3 8; 20 11
W Sagittarii	17 58.6	−29 35	4.8− 5.8	7 14.3	2 5; 9 20; 17 10; 25 0
Y Sagittarii	18 15.5	−18 54	5.8− 6.6	5 18.6	2 12; 8 6; 19 09; 31 9
U Sagittarii	26.0	−19 12	7.0− 8.3	6 17.9	3 2; 9 20; 23 7; 30 1
Y Scuti	32.6	− 8 27	8.7− 9.2	10 08.3	5 4; 15 12; 25 20
Y Lyrae	34.2	+43 52	10.5−12.	0 12.1	3 18; 9 18; 15 19; 27 21
RZ Lyrae	39.9	+32 42	9.9−11.2	0 12.3	1 8; 7 11; 19 17; 25 20
RT Scuti	44.1	−10 30	9.1− 9.7	0 11.9	3 3; 13 1; 24 22; 30 21
β Lyrae *	46.4	+33 15	3.4− 4.5	12 21.8	4 15; 17 13; 30 11
κ Pavonis	18 46.9	−67 22	4.0− 5.5	9 02.2	7 5; 16 7; 25 9
U Aquilae	19 24.0	− 7 15	6.4− 7.1	7 00.6	3 23; 11 0; 18 0; 25 1
XZ Cygni	30.4	+56 10	8.7− 9.3	0 11.2	8 13; 15 13; 22 13; 29 13
U Vulpec.	32.2	+20 07	6.9− 7 6	7 23.5	2 8; 10 8; 18 7; 26 7
SU Cygni	40.8	+29 01	6.6− 7.4	3 20.3	3 7; 10 23; 18 16; 26 8
η Aquilae	47.4	+ 0 45	3.5− 4.7	7 04.2	3 18; 10 22; 18 2; 25 6
S Sagittae	51.5	+16 22	5.6− 6.4	8 09 2	4 15; 13 0; 21 9; 29 18
X Vulpec.	19 53.3	+26 17	8.5− 9.1	6 07.7	2 12; 8 20; 21 11; 27 19
XX Cygni	20 01.3	+58 40	10.5−11.5	0 03.2	7 15; 14 9; 21 3; 27 20
V Vulpec. *	32.3	+26 15	8.0− 9 0	37 19 0	6 17
X Cygni	39.5	+35 14	6.4− 7.7	16 09 3	8 10; 24 19
T Vulpec.	47.2	+27 52	5.5− 6.5	4 10 5	3 20; 12 17; 21 14; 30 11
WZ Cygni *	49.3	+38 27	9.8−10.8	0 14.0	2 2; 7 22; 19 14; 31 7
WY Cygni	52.3	+30 03	9.5−10.3	0 13.5	1 7; 8 0; 21 11; 28 5
RV Capric.	55.9	−15 37	9.2−10.1	0 10.7	3 2; 9 20; 23 6; 29 23
TX Cygni	20 56.4	+42 12	8 5− 9.7	14 17.4	13 23; 28 17
VY Cygni	21 00.4	+39 34	8.9− 9.5	7 20.6	6 0; 13 21; 21 17; 29 14
VZ Cygni	21 47.7	+42 40	8.4− 9.2	4 20.7	2 22; 7 18; 17 12; 27 4
Y Lacertae	22 05.2	+50 33	9 1− 9.6	4 07.6	1 19; 10 11; 19 3; 27 18
δ Cephei	25.5	+57 54	3.7− 4.9	5 08.8	4 22; 10 7; 21 0; 31 18
Z Lacertae	36.9	+56 18	8.2− 9.0	10 21.1	2 4; 13 1; 23 22
RR Lacertae	37.5	+55 55	8 5− 9.2	6 10.1	7 6; 13 16; 20 2; 26 12
V Lacertae	44.5	+55 48	8.2− 8.9	4 23.6	2 23; 7 23; 17 22; 27 21
X Lacertae *	22 45.0	+55 54	8.2− 8.6	5 10.6	1 8; 6 19; 17 16; 28 13
SW Cassiop.	23 03.7	+58 12	9.2− 9.7	5 10.6	5 1; 10 12; 21 9; 26 19
RS Cassiop.	32.6	+61 52	9.1−10.0	6 07.1	1 10; 7 17; 20 7; 26 14
RY Cassiop.	47.2	+58 11	9.2−10.0	12 03.4	2 23; 15 2; 27 6
U Pegasi	23 52.9	+15 24	9.0− 9.7	0 04.5	3 13; 11 1; 18 13; 26 0

The New Variable 29.1912 Sagittae.—The following is taken from a note by Dr. E. Silbernagel in *A. N.* 4608. "By comparing some plates made in 1904 with those made here (Munich) with the 4½-inch telescope I found in the region of γ Sagittae six variable stars, five of which, however, had already been discovered by Prof. M. Wolf in 1905, and were published in *A. N.* 4079. One star, however, is new. This star at maximum is about $11^m.5$ and is situated just at the edge of a star cluster which in the B.D. catalogue is designated Nebula + 18°4290. Its position for 1900.0 is

$$\alpha = 19^h\ 49^m\ 29^s.\quad \delta = +\ 18°\ 31'\ 37''.$$

The observations were based upon the following plates.

No.	Exp. Time	Date	Mag.
1287	3 0.0	1904 Aug. 30	13.0
1288	2 36.5	Sept. 5	12.0
1292	2 36.5	Oct. 29	11.5
1438	1 2.5	1906 Oct. 20	12.0
1462	0 25.0	,, 22	12.0
1568	0 25.0	1907 Sept. 12	11.5

The star was probably at a minimum on Aug. 30, 1904, at a maximum on Oct. 29, 1904, and has apparently a period which is probably not much greater than 120 days. For facilitating the identification of the star the accompanying chart is given which besides the variable contains also all the stars in the neighborhood of nearly the same brightness, the star cluster and the star 1 = BD + 18°4283 which was used a comparison star.

"In the following table are given the magnitude observations of the five stars mentioned above in the neighborhood of γ Sagittae as well as those of five stars in the neighborhood of γ Aquilae, which likewise have been discovered by M. Wolf and published in *A. N.* 3959. The estimates are expressed to the nearest half magnitude unit because closer determinations were not possible. The observations of the stars 129, 143, 145, 160, 166.1905 Sagittae are based upon the plates mentioned above, but for the determination of the brightness of the stars SV, RV, RY, ST, RZ Aquilae the following plates were used.

No.	Exp. time h m	Date
1272	2 36	1904 July 11-12
1277	3 0	Aug. 4
1388	2 36	1905 July 27
1394	1 2	Aug. 4

Variable	Magnitude 1904 Aug. 30	1904 Sept. 5	1904 Oct. 29	1906 Oct. 20	1906 Oct. 22
	m	m	m	m	m
129.1905 Sagittæ	13.5	13.0	<15	<14	13.5
143 1905 "	13.0	13.5	<15	<14	<13.0
145.1905 "	13.0	12.5	13.0	14?	<13.0
160.1905 "	10.5	10.5	<15	<13.5	<13.0
166.1905 "	12.5	12.0	14.5	<13.5	<13.0

	1904 July 11	1904 Aug. 4	1905 July 27	1905 Aug. 4
	m	m	m	m
SV Aquilæ	13.5	13.5	<14.5	<14.0
RV "	12.5	<13.5	10 5	10.5
RY "	10.0	11.0	11.5	12.0
ST "	<14	<14	12 5	12.5
RZ "	11.5	12.5	13.0	13.0

Variable Star Atlas.—We have recently added to the library of the Goodsell Observatory the "Atlas Stellarum Variabilium." Mention was made in this Journal a number of years ago concerning this work when the project was begun. Because of the size which this Atlas has attained and because of the important place it fills in the work of variable star investigation we desire to make a further note concerning it. This Atlas is the work of Rev. J. G. Hagen now of the Specola Vaticana, Rome. It was begun in 1890, at which time Rev. Hagen was the director of the Georgetown College Observatory,

Washington. It is composed of three hundred and eleven charts and a catalogue sheet for each. The purpose of the atlas is to furnish means for identifying the several variables, and also to furnish the relative brightness of the comparison stars in the region of the variable. The charts are arranged in six series, five of which are determined according to position in the sky and according to the brightness of the respective variables at maximum and minimum; the sixth series is supplementary. In each chart the variable is placed at the center. In the region about the variable all the BD. stars are plotted. In a smaller region about the variable are plotted, in addition to the BD. stars, all the stars visible in the Georgetown twelve inch equatorial. The positions of the BD. stars were carefully verified, and the positions of all fainter stars were determined by Rev. Hagen. The catalogue sheet gives the positions of all stars on the chart in terms of distances in right ascension and declination from the variable. The coördinate lines on the charts are printed in red, so that when used with a ruby light at the telescope these lines do not appear and one has an exact picture of the configuration of stars without any lines to modify the appearance. Besides the positions of the stars, the sequences of brightness are also given. By a linear formula,

$$\text{Magn.} = a + b\,(\text{Grade} - c),$$

the grades were changed into magnitudes so that they should agree as nearly as possible with the BD. scale of magnitudes between the seventh and the tenth.

This atlas is considered a very valuable addition to our library. It was purchased from Felix L. Dames, Berlin.

COMET AND ASTEROID NOTES.

Minor Planet 1911 MT.—In the *Lick Observatory Bulletin* No. 220. Mr. E. S. Haynes, of the Berkeley Astronomical Department, gives new elements of 1911 MT, using the Heidelberg position of the planet on Sept. 16, 1911 and two normal places based on the observations on Oct. 4, and Oct. 11, These agree very closely with the former elements published in the L. O. Bulletin No. 216.

ELEMENTS VI.

$T = 1911$, Aug. 29.1322 Gr. M.T.
$\omega = 152^\circ\ 00'\ 27''$
$\Omega = 185\ \ 32\ \ 38$ } 1911.0
$i = \ \ 10\ \ 47\ \ 36$
$e = 0.537675$
$a = 2.56793$
$\mu = 862''.248$
Period = 4.1150 years.

In *A.N.* 4608 Mr. Ludwig von Tolnay, of Budapest, also gives a new determination of the orbit of MT, using the observations on Sept. 16, Oct. 4, 11, 16, 17, and 18. His results are

Epoch and Osculation 1911 Oct. 1.5, Berlin mean time

$M_0 = 7° 55' 11''.09$
$\omega = 151 \ 56 \ 42 \ .25$
$\Omega = 185 \ 32 \ 37 \ .03$ } 1911.0
$i = 10 \ 49 \ 48 \ .45$
$\phi = 32 \ 43 \ 18 \ .58$
$\mu = 853''.66483$
$\log a = 0.4124795$

He gives an ephemeris extending from 1911 July 27 to Nov. 2, during which time the planet was near enough to the earth to have been caught upon some photographic plate.

Numbering of Recently Discovered Asteroids.—In *A. N.* 4607 Dr. Fritz Cohn of the Berlin *Rechen-Institut* gives elements and permanent numbering of eighteen of the asteroids which were discovered during the year April 1911–April 1912. Circular orbits have been calculated for five more, and eleven were identified with asteroids already known. The following are the permanent numbers together with the provisional designation, discoverer, place and date of discovery:

No.	Provisional Designation	Discoverer	Place	Date
715	1911 LX	Wood	Johannesburg	1911 April 22
716	1911 MD	Palisa	Wien	1911 July 30
717	1911 MJ	Kaiser	Königstuhl	1911 Aug. 26
718	1911 MS	Palisa	Wien	1911 Sept. 29
719	1911 MT	Palisa	Wien	1911 Oct. 3
720	1911 MW	Kaiser	Königstuhl	1911 Oct. 18
721	1911 MZ	Kaiser	Königstuhl	1911 Oct. 18
722	1911 NA	Palisa	Wien	1911 Oct. 18
723	1911 NB	Palisa	Wien	1911 Oct. 21
724	1911 NC	Palisa	Wien	1911 Oct. 21
725	1911 ND	Palisa	Wien	1911 Oct. 21
726	1911 NM	Metcalf	Winchester	1911 Nov. 22
727	1912 NT	Massinger	Königstuhl	1912 Feb. 11
728	1912 NU	Palisa	Wien	1912 Feb. 16
729	1912 OD	Metcalf	Winchester	1912 Feb. 9
730	1912 OK	Palisa	Wien	1912 Apr. 10
731	1912 OQ	Massinger	Königstuhl	1912 Apr. 15
732	1912 OR	Massinger	Königstuhl	1912 Apr. 15

Encke's Comet at Aphelion.—Professor E. E. Barnard of Yerkes Observatory suggested to me not long ago that it might be possible to photograph Encke's Comet at the time of aphelion, with the powerful reflectors either at Mount Wilson or at Yerkes Observatory. At his suggestion I have just computed the enclosed six places. During the middle of April (1913), the comet will be only about $2^h \ 20^m$ west of the sun, and 8° to 10° farther south. Not very favorable.

EPHEMERIS OF ENCKE'S COMET.

Aphelion April 12, 1913.

1913	α h	m	s	δ °	′	″	log r	log Δ
Mar. 19	22	52	37	−6	29	13	0.61164	0.70180
27	22	59	6	5	44	39	0.61188	0.69834
Apr. 4	23	5	24	5	0	39	0.61202	0.69354
12	23	11	27	4	17	26	0.61208	0.68758
20	23	17	15	3	34	48	0.61204	0.68042
28	23	22	39	−2	54	58	0.61188	0.67295

F. E. SEAGRAVE.

Boston, Oct. 31, 1912.

The following extension of the ephemeris of Encke's comet through the summer and autumn of 1913 was computed in response to a request from Professor Barnard, the conditions for photographing the comet being much better then that at the time of aphelion. Professor Barnard is very anxious to photograph a comet near its aphelion.

Ephemeris of Encke's Comet July 21-Oct. 17, 1913.

1913	α			δ			log *r*	log Δ
	h	m	s	°	′	″		
July 21	23	41	17	+0	36	16	0.60402	0.52876
29	23	37	37	+0	24	12	0.60266	0.51376
Aug. 6	23	32	48	+0	4	52	0.60116	0.49990
14	23	26	53	−0	21	14	0.59958	0.48773
22	23	20	6	−0	54	6	0.59786	0.47758
30	23	12	34	−1	32	9	0.59606	0.47014
Sept 7	23	4	34	−2	14	0	0.59410	0.46563
15	22	55	50	−3	1	29	0.59202	0.46447
23	22	48	34	−3	40	49	0.58982	0.46611
Oct. 1	22	41	14	−4	21	53	0.58754	0.47097
9	22	34	44	−4	58	59	0.58502	0.47832
17	22	29	18	−5	30	40	0.58244	0.48789

F. E. Seagrave.

Comet Gale 1912.—The following observations may be of interest.

Sept. 21, 1912, 7:30 p.m. Comet found in finder; a hazy patch of light with luminous nucleus. In telescope, power 45, reminds one of globular cluster such as 47 Toucani, only center more luminous. Not visible to naked eye, but moon about ten days old, and sky not very clear. About midway between θ Centauri and β Librae.

Sept. 22. Moon very bright; sky clear; only stars of 4 or 4½ mag distinctly seen. Comet preceding and south of α Librae not far from 10 Librae.

Sept. 26. Full moon. Comet between α and β Librae; very faint owing to moolight.

Sept. 28. Comet nearest earth 69,000,000 miles away. About 1° or a little more to the east of β Librae; visible to naked eye as a very faint star; cometary nature not apparent except in finder or telescope. There is a small star, magnitude six or seven, about ¼° following. Thought I detected a tail, or that comet was wedge shaped, when looking through finder. Atmosphere a little hazy.

Sept. 30. Seen now to west of β Librae; a little brighter; estimated magnitude about 5½. Thought I detected tail but not very definite.

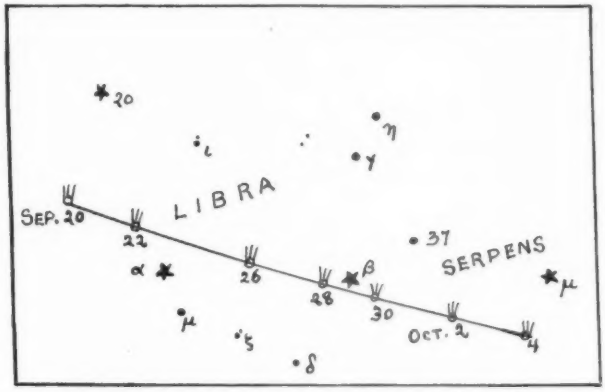
Oct. 2. Comet more easily seen with naked eye, perhaps because I know what to look for; a little below a line midway between β Librae and μ Serpentis. Sky not too clear. Appearance about the same.

Oct. 4. Now nearer μ Serpentis; seems fainter. Did not see it with the naked eye, but it is getting rather low down for observation.

Observations were made from 7:20 to about 8 p. m. on above nights. Both before and since these days the state of western sky precluded observation. Instrument 2-inch achromatic refractor.

Bernard Thomas. (M.B.C.M.)

Glenorchy, Tasmania.



APPARENT PATH OF GALE'S COMET SEPT. 20 to OCT. 4.

Ephemeris of Comet 1912 *a* (Gale.)

[From Astronomische Nachrichten No. 4607.]

Berlin Midnight	True α h	m	s	True δ °	′	log *r*	log Δ	Brightness
Nov. 30	16	29	57	+44	7.4	0.1107	0.1234	7.9
Dec. 1		31	9	44	49.0			
2		32	22	45	31.0			
3		33	38	46	13.3			
4		34	55	46	55.9	0.1296	0.1246	8.0
5		36	15	47	38.8			
6		37	36	48	22.1			
7		38	59	49	5.8			
8		40	25	49	49.8	0.1477	0.1258	8.1
9		41	53	50	34.2			
10		43	23	51	18.9			
11		44	55	52	4.0			
12		46	30	52	49.4	0.1651	0.1272	8.2
13		48	8	53	35.2			
14		49	48	54	21.3			
15		51	32	55	7.8			
16		53	19	55	54.7	0.1819	0.1290	8.3
17		55	9	56	41.9			
18		57	2	57	29.5			
19	16	58	59	58	17.3			
20	17	1	1	59	5.5	0.1980	0.1315	8.4
21		3	7	59	53.9			
22		5	18	60	42.6			
23		7	34	61	31.6			
24	17	9	57	+62	20.8	0.2134	0.1348	8.5

Comet 1912 *b* (Tuttle-Schaumasse.)—In *A. N.* 4610 Mr. G. Fayet points out that Tuttle's comet was in the vicinity of the planet Jupiter during the latter part of the year 1900, approaching at one time within 0.8 of a unit distance (Earth's distance from sun). A rough calculation of the perturbations of the comet's orbit, resulting from this approach to Jupiter, shows that the acceleration of its return to perihelion may be fully accounted for in this way.

The accompanying diagram was drawn from Rahts' elements for the apparition in 1899. The orbit of the earth and a portion of the orbit of Jupiter are projected upon the plane of the comet's orbit. The portion of the comet's path which is below the plane of the ecliptic is represented by a dotted curve; similarly the parts of the orbits of Jupiter and earth which are behind the plane of the comet's orbit in perspective are represented by dotted lines. The reader must imagine the plane of the ecliptic (Earth's orbit) to be tipped up from the plane of the diagram (rotated upon the line marked "line of nodes",) through an angle of 54°.5.

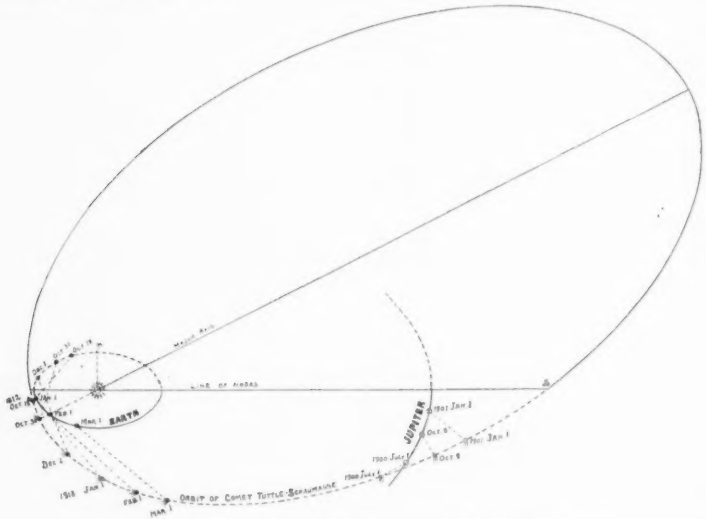


DIAGRAM OF THE ORBIT OF TUTTLE'S COMET SHOWING THE APPROACH TO JUPITER IN 1900.

The diagram shows the approach of the comet to Jupiter in 1900, and to those at all familiar with the law of gravitation it will at once be apparent why the comet's path was shortened, so that it returned two months early after its 13 year journey out from the sun and back again. No attempt has been made to indicate the change in shape and position of the orbit. The principal change has been in the length of the orbit, because of the slowing of the outward motion of the comet by Jupiter's attraction.

It appears from the diagram that observers in the southern hemisphere should be able to follow the comet for three or four months yet.

Comet 1912 *c*, **(Borrelly).**—A new comet was discovered by Borrelly, at Marseilles, on November 2. It was then about fifteen degrees west of Vega and moving southeast. It is visible in a small telescope, but is not at all conspicuous, and is growing fainter. The diagram, which we have constructed from elements by S. B. Nicholson and O. Lanzendorf of the Berkeley Astronomical Department will show to the reader the relation of the comet's orbit to

that of the earth. The comet is moving in nearly the opposite direction to that of the earth's motion, so that the relative motion is quite rapid. Its distance will become so great in December that the comet will be very faint

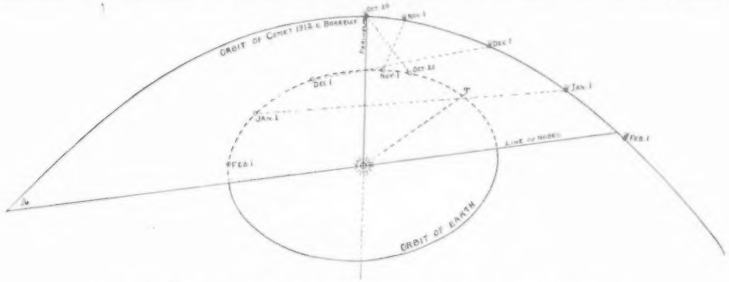


DIAGRAM OF THE ORBIT OF COMET 1912 *c* (BORRELLY.)

and may be lost sight of before the end of the month. The elements are based upon observations with only one day intervals, but they seem to represent the comet's motion very closely.

ELEMENTS OF COMET 1912 *c*.

[By S. B. Nicholson and O. Lanzendorf, *Lick Observatory Bulletin* 221.]

$$T = 1912 \text{ Oct. } 20.5270 \text{ Gr. M. T.}$$
$$\left.\begin{aligned} \omega &= 98^\circ\ 52'.5 \\ \Omega &= 143\ \ 18\ .4 \\ i &= 124\ \ 51\ .6 \end{aligned}\right\} \ 1912.0$$
$$q = 1.1054$$

CONSTANTS FOR THE EQUATOR 1912.0.

$$x = r\,[9.94029] \sin (\ 31^\circ\ 56'.7 + v)$$
$$y = r\,[9.74520] \sin (179\ \ 09\ .2 + v)$$
$$z = r\,[9.98450] \sin (113\ \ 08\ .4 + v)$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

1912	True α h m s	True δ ° ′	log Δ	Brightness
Nov. 8.5	18 32 13	+28 50.9	0.0104	0.88
12.5	18 53 56	22 54.4	0.0388	
16.5	19 11 36	17 38.2	0.0703	
20.5	19 26 18	+13 03.9	0.1031	0.51

The following observations are at hand:

Gr. M. T.	α h m s	δ ° ′ ″	Observer	Place
Nov. 3 2657	17 55 12.8	+37 21 07	.....	Arcetri
4.4892	18 04 51.41	+35 19 41.2	Duncan	Cambridge
4.5144	18 05 06.02	+35 17 08.6	Duncan	Cambridge
4.5446	18 05 20.72	+35 14 08.6	Wilson	Northfield
4.6295	18 05 58.7	+35 05 48	Aitken	Mt. Hamilton
5.2802	18 10 48.8	+34 01 21	Strömgren	Copenhagen
5.5023	18 12 24.15	+33 39 36 5	O'Connor	Cambridge
5 5566	18 12 48.62	+33 34 33.7	Wilson	Northfield
6.5861	18 19 19.61	+31 53 30.6	Wilson	Northfield
7.5621	18 26 25.33	+30 19 29.6	Wilson	Northfield
7.6388	18 26 53.88	+30 12 14.9	Aitken	Mt. Hamilton
8.5632	18 32 38.36	+28 44 45.4	Wilson	Northfield
14.5768	19 3 40.18	+20 03 44.6	Wilson	Northfield
16.5434	19 11 56.90	+17 32 22.4	Wilson	Northfield

The correction to the above ephemeris indicated by the last observation is about + 11ˢ, —2′7. Miss Myrtle L. Richmond, Fellow at Goodsell Observatory, has computed the following extension of the ephemeris for the month of December.

EPHEMERIS OF COMET 1912 *c*, (BORRELLY.)

[Computed by Myrtle L. Richmond from the elements by Nicholson and Lanzendorf.]

1912	True α	True δ	log *r*	log Δ	Br.
	h m s	° ′			
Nov. 20.5	19 26 17.6	+13 03 9	0.0843	0.1032	0.51
24.5	38 47.6	9 08.1	.0942	.1358	
28.5	49 37.6	5 45.9	.1046	.1675	
Dec. 2.5	19 59 11.6	2 52 2	.1154	.1977	0.28
6.5	20 7 46.8	+ 0 22.6	.1267	.2262	
10.5	15 36.0	— 1 46.9	.1382	.2529	
14.5	22 48.4	3 39.7	.1499	.2778	
18.5	29 31.2	5 18.5	.1616	.3009	0.14
22.5	35 50.0	6 45.7	.1734	.3224	
26.5	41 49.0	8 03.0	.1852	.3422	
30.5	47 31.2	9 11.9	.1970	.3606	
Jan. 3.5	20 52 58.4	—10 13.9	0.2086	0.3775	0.08

Borrelly's Comet 1912 *c*.—This comet was photographed on two nights with the six-inch and ten-inch lenses of the Bruce telescope.

1912 Nov. 4 exposure 2ʰ 18ᵐ
" " 6 " 3 0

The photographs show a small round head with a thin, slightly widening, faint tail over a degree long. The tail is best shown on the plate of Nov. 4. Star trails interfere on Nov. 6.

The comet was rather dim and round in the 5 inch guiding telescope.

E. E. BARNARD.

Yerkes Observatory, 1912 Nov. 20.

Conjunction of Borrelly's Comet with faint Star.—Wednesday Nov. 6, I looked up Borrelly's Comet for the first time with the eight-inch telescope and at about 5:55 p.m. eastern standard time, noted that it appeared to have a distinct stellate nucleus, centrally placed. Returning to the telescope a few minutes later I found that what I had taken for the nucleus of the comet was no longer centrally placed and was really a star of about the 10th magnitude that had been in conjunction with the comet. A few minutes later the star was entirely free from the comet.

The star is not given in the Bonn Durchmusterung, but is a little below and following BD. 32°3109.

ANNE SEWELL YOUNG.

Mount Holyoke College.

COMMUNICATIONS QUESTIONS AND ANSWERS.

A Bright Meteor.—I wish to report an unusual observation of mine on Oct. 21. I witnessed the descent of a meteor practically in daylight. It descended about 20 minutes after sunset, was intensely brilliant, and was traveling rather slowly.

When I first saw it, it was about 10 degrees south of the position of Polaris, and was moving eastward.

This is the first one I have ever seen so soon after sunset.

W. H. CASSELL, M. D.

Wytheville, Va. Nov. 1, 1912.

Since reporting my large meteor, I have witnessed another of a similar nature. I observed an exceedingly large one on Nov. 3, 1912 at 6:30 p. m. It came from the same locality as the other, was unusually large and was moving westward, whereas the first one moved eastward.

My only object in reporting these two occurrences is the very unusually large size of the meteors.

W. H. CASSELL, M. D.

Wytheville, Va. Nov. 4, 1912.

A Daylight Meteor.—The phenomenon of a meteor is so seldom observed in full sunlight that the following account, extracted from a private letter, by a young lady at Asheville, N. C., who evidently has had on training in observing meteors is, perhaps, worth recording.

"On last Tuesday, October 29, I was at a corner waiting for the streetcar and had my back to the east; the sun was on its way to bed, but was still quite high and most brilliant.....Some impulse made me turn around, so my back was toward the sun. I merely chanced to look skyward and there, going right across my vision was a star with a tail. It went, I imagine, 200 or 300 feet and then disappeared. Its head to my eye looked about four to six inches in size, longer than wide, and of a deep violet blue color; the tail was brilliant yellow. I could almost imagine I heard the 'swish' through the air. It was beautiful; the sky was a turquoise blue and the sun shining directly on it. My first thought was 'Oh, a shooting star'. Then I remembered stars could not be seen in sunlight—and such sunlight too! So, again I thought, could it be a meteor? It seemed so near the earth, though; do they still blaze when they get so near? This seemed just above the hill tops. It did not seem to be headed downward (as falling from the sky) but was shooting across in due southwest direction. M. B. COWAN."

Center of Gravity of Earth and Moon.—QUESTION.—How far from the earth's center of gravity is the common center of gravity between the earth and moon, when they are at their mean distance apart?

ANSWER.—The moon's mass or weight is 1/81.5 of that of the earth, so the center of gravity of the two should be 1/82.5 of the moon's mean distance, or about 2895 miles from the center of the earth. That is to say, the center of gravity of the two is over 1000 miles below the surface of the earth.

Stellar Parallax and the Sun's Motion.—I read in Oct. No. page 535 in the article "An instance of Scientific Accuracy": "The measuring of the parallax of the nearest star, or angle subtended by the diameter of the earth's orbit at the distance of the star" etc., and I have often read similar statements in other works. Now since the sun is said to be moving through space at the rate of 12 miles a second I do not see how any dependence could be put on this base for calculations, even when the star is in front of or behind the sun in her path, the earth's orbit being a spiral coil about the sun's way. On the other hand a great base could be had on stars at right angles to the sun's path, by taking observations of them at times 5, 10, 20 or even 50 years apart. Will some one please explain?"

G. M. CROWL.

Los Angeles, Cal.

ANSWER.—The querist is right in thinking that the displacement of a star because of the earth's motion along with the sun is much greater than that produced by its annual motion around the sun. The former effect is, however, involved with that due to the star's own motion, so that it cannot be disentangled from what is called the proper motion of the star. The principle the querist suggests has been used in the case of averages of large numbers of stars of the same class, where the number is large enough and the stars widely enough scattered to permit the assumption that the average of their own proper motions is zero.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers Oct.-Nov. 1912.—It is a pleasure to report that this month the Association has established a new record for the number of observations contributed, a total of 1035,—truly a fine example of what coöperation in observing can accomplish.

Dr. Gray deserves a reward of merit for his splendid list of 247 observations. It is a record that will stand for some time, testifying to his persistence and nutiring energy. We all envy him the good weather that enabled him to make so many observations, he having observed on twenty seven nights in the month. The efficient service Dr. Gray is rendering our Association is largely responsible for its progress and success.

The variable star 213843 SS Cygni has been closely followed in its wane by a majority of our observers. The observations of Oct. 14 and 15 show how well it was observed, and a mean of these estimates should be close to the exact magnitude. Maxima of 001726 T Andromedae, and 004047 U Cassiopeiae were observed during the month, both in close accordance with Hartwig's calculations.

The variable 194632 Chi Cygni began to wane about the third week in Oct., and rapidly disappeared from naked eye view. The wane was exceedingly well observed.

230110 R Pegasi, 210868 T Cephei and *184205* R Scuti can be observed at present to advantage with a field glass, which is to be preferred to the telescope when the variable is bright.

VARIABLE STAR OBSERVATIONS Oct.–Nov., 1912.

001755 T Cassiopeiae

Mo.	Day	Est.	Obs
10	4	8.1	G
	4	8.7	Bu
	6	8.5	Bu
	8	9.0	C
	8	8.8	Bu
	10	9.0	C
	11	8.6	L
	11	8.1	G
	14	9.1	J
	14	8.1	B
	17	8.2	G
	17	8.9	J
	19	8.9	J
	22	9.0	Bu
	26	9.1	J
	29	9.0	Bu
	30	8.4	Y
	31	8.3	G
	31	9.2	J
11	3	9.2	J
	6	9.2	S

001726 T Androm.

Mo.	Day	Est.	Obs
10	7	8.2	G
	11	8.4	G
	12	8.6	O
	14	8.6	S
	15	8.6	O
	16	8.2	G
	20	8.6	O
	28	9.0	O
	29	8.3	G
	30	9.2	Y
11	3	9 5	O
	5	9.6	S
	6	9.5	O

001909 S Ceti

Mo.	Day	Est.	Obs
10	14	9.5	G

004047 U Cassiopeiae

Mo.	Day	Est.	Obs
10	10	8.2	G
	12	8.0	G
	14	8 6	S
	14	8.6	Y
	15	8.3	G
	16	8.2	G
	20	8.4	O
	21	8.5	Y
	21	8.1	G
	26	8.1	G
	28	8.8	O
	29	8.2	G
	30	8.7	Y
11	3	9.2	O
	6	9.0	O

004533 RR Androm.

Mo.	Day	Est.	Obs
11	4	12.2	O

004958 W Cassiopeiae

Mo.	Day	Est.	Obs
10	4	11.7	J
	16	11.8	J
	19	11.9	J
	28	11.7	J
	30	11.6	J
	31	11.6	J
11	1	11.4	J
	3	11.7	J
	8	11.8	J

011208 S Piscium

Mo.	Day	Est.	Obs
10	14	10.1	O
	14	10.3	Y
	30	10.5	Y
11	3	10.7	O
	4	11.1	O

012502 R Piscium

Mo.	Day	Est.	Obs
10	14	12.5	Y
	30	12.5	Y

013338 Y Androm.

Mo.	Day	Est.	Obs
10	14	9.7	J
	17	9.8	J
	19	9.8	J
	28	9.9	J
	30	10.0	J
	31	9.8	J
11	4	10.2	J
	8	10.1	J

014958 X Cassiopeiae

Mo.	Day	Est.	Obs
10	12	11.3	L

021024 R Arietis

Mo.	Day	Est.	Obs
10	2	9.2	G
	8	9.3	C
	10	9.4	C
	14	9.8	O
	18	11.0	G
	20	10.2	O

021258 a T Persei

Mo.	Day	Est.	Obs
10	8	8.8	C
	10	8.8	C
	13	8.9	C
	15	8.8	B
	28	8.9	B
	29	9.5	M
	30	8 9	C
11	6	8.9	O

021403 o Ceti

Mo.	Day	Est.	Obs
10	4	7.4	G
	5	7.4	G
	5	7.2	Bu
	6	8.0	C
	6	7.2	Bu
	8	7.5	Bu
	8	8.0	C
	8	7.5	G
	10	8.1	C
	10	7.5	G
	11	7.9	L
	13	7.8	F
	13	8.3	V
	14	8.0	O
	14	8.0	L
	15	8.1	L
	16	8.4	O
	18	7.9	G
	19	8.6	F
	22	7.5	Bu
	29	7.5	Bu
	30	8.5	G
	30	8.2	Hu
	30	8.6	C
11	2	8.7	O
	3	8.5	V

021558 S Persei

Mo.	Day	Est.	Obs
10	8	9.5	C
	10	9.3	C
	13	9.4	G
	13	9.4	C
	15	8.9	B
	21	8.6	G
	28	9.5	B
	29	9.0	G
	29	9.3	M
	30	9.3	C
	31	9.2	G
11	3	9.2	O
	6	9.0	O

022813 U Ceti

Mo.	Day	Est.	Obs
10	8	9.6	C
	10	9.7	C
	29	9.4	Bu

023133 R Trianguli

Mo.	Day	Est.	Obs
10	3	9.7	G
	15	9.4	Y
	15	9.5	O
	16	9.4	G
	30	9.8	Y
	30	9.7	G
11	3	10.7	O
	8	10.2	O

024356 W Persei

Mo.	Day	Est.	Obs
10	13	10.0	G
	13	9.4	Le
	13	9.0	V
	14	9.5	Le
	15	9.5	Le
	15	10.0	O
	16	9.5	Le
	16	9.2	Hu
	17	9.5	Le
	18	9.5	Le
	19	9 5	Le
	21	9.6	G
	23	9.2	Le
	24	9.0	Le
	25	9.2	Le
	26	9.5	Le
	27	9.3	Le
	28	9.5	Le
	29	9.3	Le
	31	9.2	G
11	2	9.4	Le
	2	9.2	Hu
	3	9.3	Le
	3	9.2	O
	3	9.0	V
	4	9.2	Le

032043 Y Persei

Mo.	Day	Est.	Obs
10	13	9.4	G
	14	8.6	Hu
	21	9.6	O
	21	8.6	G
	29	8.3	G
11	2	8.2	Hu
	3	9.5	O
	6	9.3	O

032335 R Persei

Mo.	Day	Est.	Obs
10	14	10.4	Y
	30	9.9	Y
11	5	9.0	S

034625 U Eridani

Mo.	Day	Est.	Obs
10	15	9.1	G

035124 T Eridani

Mo.	Day	Est.	Obs
10	15	9.3	G

035916 V Eridani

Mo.	Day	Est.	Obs
10	15	8.8	G
	21	8.6	G

042215 W Tauri

Mo.	Day	Est.	Obs
10	12	10.7	G
	15	10.0	G
	15	11.3	Y
	31	9.5	G
11	2	12.1	Y

043065 T Camelop.

Mo.	Day	Est.	Obs
11	2	13.4	Y

043274 X Camelop.

Mo.	Day	Est.	Obs
10	14	8.5	Y
	14	8.3	O
	16	8.3	G
	18	8.3	G
	29	8.3	G
	31	9.8	Y
11	2	10.3	O
	6	10.6	O

045307 R Orionis

Mo.	Day	Est.	Obs
11	2	12.5	Y

045514 R Leporis

Mo.	Day	Est.	Obs
10	11	9.3	L
	12	8.7	G
	14	9.3	L
	15	8.9	G
	17	9.0	C
	18	8 8	G
	19	8.4	F
	20	7.4	M
	21	9.0	G

050022 T Leporis

Mo.	Day	Est.	Obs
10	18	9.0	G

050953 R Aurigae

Mo.	Day	Est.	Obs
10	8	8.4	C
	14	8.5	J
	16	8.5	O
	17	8.5	J
	19	8.6	J
	20	8.2	M
	21	8.3	Y
	26	8.6	J
	28	8.4	B
	30	8.6	J
	31	8.7	J
11	2	8.2	Y
	4	8.8	J
	6	8.4	B

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052034
S Aurigae

Mo.	Day	Est.	Obs.
10	15	10.0	L
	15	9.2	Y
	31	9.2	Y

053068
S Camelop.

Mo.	Day	Est.	Obs.
10	14	9.2	Y
	21	8.9	Y
11	2	8.8	Y

054319
SU Tauri

Mo.	Day	Est.	Obs.
10	14	10.2	Y
11	2	10.4	Y

054920
U Orionis

Mo.	Day	Est.	Obs.
10	8	9 4	C
	12	9.7	G
	17	9.6	C
	19	10.7	G

055353
Z Aurigae

Mo.	Day	Est.	Obs.
10	15	9.9	Y
	21	9.9	Y
11	2	9.6	Y

060355
R Lyncis

Mo.	Day	Est.	Obs.
10	21	12.5	Y
	31	11.7	Y

070310
R Can. Min.

Mo.	Day	Est.	Obs.
10	21	8.1	G

072708
S Can. Min.

Mo.	Day	Est.	Obs.
10	18	11.8	G

073508
U Can Min.

Mo.	Day	Est.	Obs.
10	11	8.9	L
	12	8.4	G
	18	8.3	G
	21	8.5	G

074922
U Geminorum

Mo.	Day	Est.	Obs.
11	4	10.7	J
	5	10.3	J

081112
R Cancri

Mo.	Day	Est.	Obs.
10	17	9.3	C

081617
V Cancri

Mo.	Day	Est.	Obs.
10	19	11.0	F

085120
T Cancri

Mo.	Day	Est.	Obs.
10	15	9.1	L

093178
Y Draconis

Mo.	Day	Est.	Obs.
10	14	10.6	Y
	21	9.7	Y
11	2	9.1	Y

094211
R Leonis

Mo.	Day	Est.	Obs.
10	11	10.1	L
	12	9.7	G
	14	10.3	L
	17	9.2	C
	18	10.2	G

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
9	27	8.0	L
10	2	8.0	L
	3	7.8	G
	4	7.9	Bu
	6	8.2	Bu
	8	8.0	Bu
	9	8.2	G
	11	8.2	L
	13	8.0	F
	13	8.2	B
	13	8.3	L
	14	8.2	B
	14	8.4	L
	15	8.3	L
	16	8.8	J
	17	8.3	C
	17	8.4	L
	18	8.2	G
	19	8.0	F
	19	9.0	J
	20	8.4	L
	22	8.2	Bu
	26	8.5	L
	28	8.4	B
	30	8.8	J
11	2	8.6	B
	4	8 6	J
	4	9.0	M

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
10	14	10.3	Y
	28	9.1	J
	31	8.6	Y
11	3	9.0	J
	4	9.0	Y

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
10	14	10.7	Y
	14	10.6	L
	15	10.5	L
	16	10.3	J
	17	10.4	L
	19	10.5	F
	19	10.2	J
	26	9.6	J

S Urs. Maj.

Mo.	Day	Est.	Obs.
10	27	9.5	F
	27	9.5	J
	31	8.8	Y
11	3	9.2	J
	4	9.1	M

134440
R Can. Ven.

Mo.	Day	Est.	Obs.
10	2	10.5	G
	14	10.5	L

141567
U Urs. Min.

Mo.	Day	Est.	Obs.
10	16	11.3	J
11	3	11.8	J

141954
S Boötis

Mo.	Day	Est.	Obs.
10	14	9.5	J
	16	9.5	J
	16	9.0	G
	16	9.4	S
	25	8.6	G
	28	9.4	J
	30	9 5	J
	31	8.3	G
11	3	9.8	J

142539
V Boötis

Mo.	Day	Est.	Obs.
9	28	8.8	L
10	5	8.3	G
	9	8.2	G
	11	8.2	L
	11	8.8	V
	14	8.3	L
	15	8.2	L
	16	7.9	S
	16	7.9	G
	18	7.8	G
	19	8.3	L
	20	7.9	L
	26	7.9	L
	27	7.7	G
	30	7.7	G

142584
R Camelop.

Mo.	Day	Est.	Obs.
10	2	8.9	L
	4	8.8	Bu
	5	8 9	G
	6	9.0	Bu
	8	9.0	Bu
	8	9.0	C
	9	8.9	G
	10	9.0	C
	12	9.2	L
	12	9.3	O
	14	8.9	J
	14	9.0	G
	14	8.9	B
	15	9.0	L

R Camelop.

Mo.	Day	Est.	Obs.
10	16	9.3	O
	16	8.9	G
	16	9.1	J
	19	9.1	J
	19	9.5	L
	20	9.4	O
	22	9.2	Bu
	23	9.4	G
	25	9.4	G
	26	9.2	J
	27	9.8	O
	28	9.3	B
	28	9.4	J
	29	9.5	G
	30	9.7	J
	31	9.9	J
11	2	10.0	O
	2	9.7	B
	3	9.8	J
	6	10.1	B
	6	10.1	O

143227
R Boötis

Mo.	Day	Est.	Obs.
10	11	7.9	L
	14	7.7	L
	16	7.6	S
	17	7.7	L
	19	7.5	L
	20	7.5	L
	26	7.3	L

151731
S Cor. Bor.

Mo.	Day	Est.	Obs.
10	25	10.2	G
	27	10.0	G

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
10	2	8.5	L
	9	8.4	G
	13	8.4	L
	15	8.5	L
	20	8.3	L
	24	8.3	G
	31	8 2	G

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
9	28	6.0	L
10	2	6.0	L
	4	6.4	G
	5	6.4	G
	6	6.0	C
	6	6.4	Bu
	9	6.2	G
	11	6.1	L
	11	6.7	G
	12	6.1	O
	12	6.0	L
	12	6.4	G
	13	6.0	F
	14	6.1	O

R Cor. Bor.

Mo.	Day	Est.	Obs.
10	14	6.0	S
	14	6.0	L
	15	6.1	O
	15	6.1	J
	16	6.1	O
	16	6.0	G
	17	5.9	C
	17	6.0	L
	18	6.2	G
	19	6.5	G
	19	6.1	L
	19	6.1	J
	20	6.0	L
	24	5.8	G
	25	6.0	G
	26	6.1	J
	27	6.1	L
	27	6.0	F
	27	6.0	G
	29	5.8	G
	30	6.0	G
	31	5.8	C
11	3	6.4	J

154440
V Cor. Bor.

Mo.	Day	Est.	Obs.
10	16	11.7	G

154536
X Cor. Bor.

Mo.	Day	Est.	Obs.
10	30	12.7	J

155847
X Herculis

Mo.	Day	Est.	Obs.
9	27	6.0	L
10	12	6 0	L
	14	5.9	L
	19	6.1	L
	26	5.9	L

162119
U Herculis

Mo.	Day	Est.	Obs.
10	28	11.6	Y

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
10	4	9.4	Bu
	6	9.0	Bu
	8	9.0	Bu
	15	9.6	O
	22	9.0	Bu
	29	9.2	Bu

163266
R Draconis

Mo.	Day	Est.	Obs.
10	13	10.5	L
	14	10.3	Y
	14	10.4	J
	15	10.2	L
	16	10.6	J
	17	10.3	F
	19	10.3	J
	19	10.2	L
	20	10.0	L

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R Draconis

Mo.	Day	Est.	Obs.
10	21	9.4	Y
	26	9.3	L
	26	9.3	J
	28	9.2	J
	28	8.9	B
	31	9.0	J
11	3	8.7	J
	8	8.2	O
	8	8.3	O

164715

S Herculis

Mo.	Day	Est.	Obs.
10	12	8.8	O
	12	8.8	G
	14	8.7	J
	16	8.9	J
	27	8 5	G
	30	8.5	G
	30	8.7	J
11	3	8.6	J

165631

RV Herculis

Mo.	Day	Est.	Obs.
10	12	9.7	G
	15	9.9	O
	15	9.4	Y
	20	9.9	O
	27	9.5	G
	30	9.6	G
11	8	10.5	O

175458

T Draconis

Mo.	Day	Est.	Obs.
10	7	10.5	V
	13	10.5	V
	17	10.9	F
11	6	10.3	O

180531

T Herculis

Mo.	Day	Est.	Obs.
10	6	11.0	Hu
	6	11.0	C
	8	10.5	C
	10	10.5	C
	12	10.5	G
	13	10 5	C
	15	10.0	O
	26	9.2	M
	27	9.1	O
	27	9.2	M
	28	9.3	B
	29	9 1	M
	30	9.0	G
	30	9.2	C
11	2	8.9	V
	3	9.0	O
	6	8.7	O

181136

W Lyrae

Mo.	Day	Est.	Obs.
10	6	10.1	Hu
	10	9.5	C
	13	9.4	C
	15	9.4	O
	17	9.7	G
	19	10.0	G
	20	9.2	O
	21	9.2	Y
	23	10.4	G
	27	9 0	O
	30	9.0	Y
	30	8.6	C
11	2	8.9	Hu
	3	8.9	O
	5	8.8	O

184205

R Scuti

Mo.	Day	Est.	Obs.
9	27	5.2	L
10	8	5.9	C
	10	5.9	C
	11	5.6	L
	12	5.6	L
	13	5.9	F
	13	6.2	G
	13	5.8	C
	14	5.4	L
	14	5.8	M
	15	5.8	O
	17	5.8	L
	17	6.1	G
	19	5.6	M
	19	5.4	L
	20	5.4	L
	23	5.3	L
	26	5.4	L
	27	5.4	L
	27	4.9	M
	27	5.7	C
	27	5.7	F
	29	4.8	M
	30	5.7	C
11	8	5.8	O

190967

U Draconis

Mo.	Day	Est.	Obs.
10	20	12.1	Hu

193449

R Cygni

Mo.	Day	Est.	Obs.
10	6	12.6	Hu
	26	13.6	M

193732

TT Cygni

Mo.	Day	Est.	Obs.
10	3	7.8	G
	6	8.1	C
	8	8.1	C
	8	7.8	G

TT Cygni

Mo.	Day	Est.	Obs.
10	10	8.1	C
	31	8.1	C
	14	8.0	G
	24	7.8	G
	30	8.5	C

194048

RT Cygni

Mo.	Day	Est.	Obs.
9	27	8.4	L
10	3	8.3	G
	4	8.8	Bu
	5	8 3	G
	6	8.3	C
	7	8.4	G
	8	9.3	Bu
	10	8.5	C
	11	8.5	G
	11	8.8	L
	13	8.6	C
	13	8.9	L
	13	8.7	F
	14	8.5	G
	14	9.0	O
	14	8.5	M
	17	8.6	M
	19	8.8	F
	19	9.3	L
	19	8.6	M
	20	8.8	O
	22	9.5	Bu
	26	9.0	Y
	26	9.7	L
	26	8.6	G
	29	9 3	G
	29	9.5	Bu
	30	9.3	C
	31	9.3	Y
11	1	9.4	Y
	2	9.8	O
	3	9.3	F
	5	9.8	S

194348

TU Cygni

Mo.	Day	Est.	Obs.
10	10	10.5	G
	13	9.4	F
	14	10.2	M
	17	10.5	M
	19	9.6	F
	19	10.6	M
	31	10.4	M
11	1	10.5	M
	3	9.0	F

194632

χ Cygni

Mo.	Day	Est.	Obs.
9	27	4.6	L
10	3	4.9	G
	5	6.2	Bu
	6	5.2	C

χ Cygni

Mo.	Day	Est.	Obs.
19	6	5.8	Bu
	6	5.1	Hu
	8	4.9	G
	8	5.3	M
	8	5.2	C
	8	5.8	Bu
	10	5 1	C
	11	5.0	L
	12	4.8	G
	12	5.4	O
	13	5.0	F
	13	5.2	C
	13	4.9	L
	14	5.4	J
	14	5.3	O
	14	5 1	L
	14	5.0	Hu
	14	5.0	G
	15	5.3	O
	15	5.8	M
	16	5.2	G
	16	5.3	O
	16	5.4	J
	17	5.2	G
	17	5.3	L
	18	5.4	O
	19	5.6	J
	19	5.2	L
	19	5.3	F
	20	5.4	O
	21	5.2	G
	22	6.0	Bu
	23	5.7	L
	23	5.3	G
	26	5.9	J
	26	5.8	L
	26	5.6	O
	26	5.5	G
	27	5.8	L
	27	5.4	G
	28	6.1	O
	28	5.8	J
	28	5.6	B
	29	5.4	G
	29	6.0	M
	29	6.0	Bu
	30	6.2	C
	30	5.6	Hu
	30	5.9	J
	31	6.1	J
11	2	6.2	O
	3	6.0	F
	3	6.3	J
	6	6.4	O
	8	6.6	J

200325

W Vulpeculæ

Mo.	Day	Est.	Obs.
10	10	9.5	G

200647

SV Cygni

Mo.	Day	Est.	Obs.
10	3	9.0	G
	6	9.2	C
	6	9.2	Bu
	7	8.0	Hu
	10	9.4	C
	13	9 4	F
	15	9.1	M
	18	9 2	G
	19	9.2	F
	22	9.0	Bu
	25	9.2	G
	27	9.2	M
	28	8.7	B
	29	9.4	Bu
	30	9.2	C
	30	8.0	Hu
11	2	8.9	B
	6	8.5	B
	6	9.5	O

200715 a

S Aquilae

Mo.	Day	Est.	Obs.
10	13	10.0	F
	15	10.4	M
	27	10.0	F

200715 b

RW Aquilae

Mo.	Day	Est.	Obs.
10	13	9.4	F
	27	9.0	F

200916

R Sagittae

Mo.	Day	Est.	Obs.
10	13	9.5	F
	27	9.1	F

200938

RS Cygni

Mo.	Day	Est.	Obs.
10	3	7.2	G
	5	7.4	G
	6	7.5	Bu
	8	7.8	C
	8	7.7	Bu
	13	7.2	F
	13	7.4	G
	14	8.3	J
	17	8.7	J
	19	8.7	J
	19	7.6	F
	22	8.0	Bu
	24	7.4	G
	26	8.7	J
	29	7.8	Bu
	30	8.6	J
11	3	8.3	J
	8	8.5	J

201008

R Delphini

Mo.	Day	Est.	Obs.
10	8	12.6	B

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201521
RT Capricorni

Mo.	Day	Est.	Obs.
10	7	7.0	G
	10	6.6	G
	11	6.5	G
	12	6.4	G
	13	6.4	G
	14	6.3	G
	16	6.4	G
	21	6.3	G
	24	6.2	G
	25	6.3	G
	29	6.3	G
	31	6.3	G

201647
U Cygni

10	5	10.4	G
	11	11.3	L
	13	10.2	F
	14	10.8	O
	14	10.7	J
	15	10.7	J
	16	10.4	G
	19	10.0	F
	19	11.0	J
	23	10.5	G
	26	10.9	J
	30	10.8	G
	30	11.2	J
11	3	11.3	J
	8	11.5	J

202846
TV Cygni

9	27	9.7	L
10	12	9.8	L
	13	9.8	L

202946
SZ Cygni

9	27	9.6	L
10	3	9.1	G
	4	9.3	G
	6	9.5	Bu
	6	9.6	G
	7	9.4	Hu
	7	9.8	G
	8	9.2	Bu
	8	9.8	B
	8	10.0	G
	9	10.0	G
	10	9.6	G
	11	9.3	G
	12	9.3	L
	12	8.9	G
	13	8.8	C
	13	9.1	L
	13	8.6	G
	13	9.3	F
	14	8.6	G
	15	8.6	G
	16	8.9	G
	17	9.2	G

SZ Cygni

Mo.	Day	Est.	Obs.
10	18	9.4	G
	19	9.4	F
	19	9.7	G
	20	9.8	G
	21	9.9	G
	22	9.2	Bu
	23	9.9	G
	24	9.6	G
	25	9.5	G
	26	9.3	G
	27	8.9	G
	28	8.7	B
	29	8.5	G
	29	9.2	Bu
	30	8.6	G
	30	9.4	C
	30	9.0	Hu
	31	8.8	G
11	2	8.9	B
	2	9.4	Le
	3	9.5	Le
	4	9.5	Le
	6	9.7	B

203816
S Delphini

10	14	10 9	Y
11	2	10.1	Y

203847
V Cygni

10	14	9.9	G
	20	9.9	G
	30	9.5	G

204016
T Delphini

10	14	12.8	Y
11	2	11.4	Y

204405
T Aquarii

10	15	10.5	J
	21	10.4	J
	26	9.9	J
	28	9.7	J
	30	9.7	J
	30	8.9	Hu
11	2	9.4	V
	3	9.3	J
	4	9.5	O
	8	9.4	J

204846
RZ Cygni

10	31	11.3	Y

205923
R Vulpeculae

10	14	11.6	Hu
11	3	10.8	J
	3	9.8	Hu
	6	9.5	O

210116
RS Capricorni

Mo.	Day	Est.	Obs.
10	6	8.2	C
	7	8.0	G
	8	8.4	C
	9	8.0	G
	10	8.4	C
	12	8.0	G
	13	8.4	C
	21	8.0	G
	30	8 3	C
	30	7.9	G

210868
T Cephei

9	27	5.9	L
10	5	6.5	Bu
	7	6.4	V
	8	6.2	Bu
	8	6.1	M
	8	6.0	C
	9	5.5	G
	10	5.9	C
	11	6.5	L
	13	6.4	V
	13	6.0	C
	13	6.0	L
	14	6.3	M
	14	6.4	J
	15	6.2	L
	16	6.2	O
	16	5.9	J
	17	6.2	L
	19	5.2	G
	19	6.3	J
	19	6.2	L
	19	6.7	M
	20	6.3	L
	22	6.5	Bu
	26	6.4	L
	26	6.6	J
	27	6.3	L
	28	6.4	O
	29	6.5	Bu
	30	6.7	M
	30	7.0	C
	31	5.5	G
	31	6.4	J
	31	6.6	J
11	3	6.8	J
	3	6.9	V
	6	6 7	O
	8	6.9	J

213244
W Cygni

9	27	6.3	L
	28	6.4	L
10	4	6.5	G
	5	6.5	G
	6	6 5	C
	10	6.0	C

W Cygni

Mo.	Day	Est.	Obs.
10	10	6.5	G
	13	6.1	C
	14	5.4	L
	15	5.5	L
	17	6.4	G
	30	5.7	C

213753
RU Cygni

10	4	8.3	G
	21	8.2	G

213843
SS Cygni

10	3	8 4	G
	4	8.3	G
	5	8.4	G
	5	8.2	Hu
	6	8.4	G
	6	8.2	C
	6	8.2	Hu
	7	8.5	G
	7	8.2	Hu
	7	8.3	V
	8	8.4	M
	8	8.5	G
	8	8.7	Y
	8	8.2	Bu
	8	8.2	C
	9	8.6	G
	9	8.4	J
	10	8.5	G
	10	8.2	V
	10	8.4	C
	11	8.3	J
	11	8.6	G
	12	8.5	Le
	12	8.3	O
	12	8.6	G
	13	8.5	Le
	13	8.4	C
	13	8.6	G
	14	8.5	S
	14	8.9	Y
	14	8.3	L
	14	8.5	M
	14	8.3	O
	14	8.5	Le
	14	8.8	Hu
	14	8.7	G
	14	8.6	J
	15	8.7	Le
	15	9.1	V
	15	8.5	O
	15	8.7	G
	15	8.7	J
	15	9.1	L
	15	9.1	Y
	15	8.6	M
	16	9.1	Le
	16	9.4	J
	16	8.7	O

SS Cygni

Mo.	Day	Est.	Obs.
10	16	8.8	S
	16	9.4	Hu
	16	9.4	G
	17	9.8	J
	17	9.5	M
	17	9.3	Le
	17	9.7	G
	18	9.7	Y
	18	9.4	O
	18	9.8	Hn
	18	9.6	Le
	18	10.2	G
	19	10.6	G
	19	10.9	G
	19	10.0	M
	19	10.8	F
	19	10 0	Le
	19	10 3	J
	20	11.0	G
	20	11.1	J
	20	10.5	O
	21	11.4	J
	21	11.5	G
	21	11.5	Y
	22	10.8	Bu
	26	11.8	J
	26	12.0	M
	28	11.8	J
	29	11.0	Bu
	30	11.9	Hu
	30	11.9	J
	31	11.7	Y
	31	11.9	J
11	2	12.0	J
	3	11.6	Hu
	3	12.0	J

213937
RV Cygni

10	7	7 5	Hu
	8	8.1	C
	10	8.2	C
	10	7.9	G
	12	8.0	Le
	13	8.1	Le
	14	8.4	J
	14	8.0	Le
	15	8.0	Le
	16	8.1	Le
	17	8.0	Le
	17	8.5	J
	18	7.9	Le
	19	8.4	J
	19	8.0	Le
	19	8.1	G
	19	6.9	F
	20	8.1	Le
	23	8.0	Le
	24	8.1	Le
	25	7.9	Le
	26	8.4	J

VARIABLE STAR OBSERVATIONS Oct.–Nov. 1912—Concluded.

RV Cygni

Mo.	Day	Est.	Obs.
10	26	7.8	Le
	27	8.0	Le
	28	8.0	Le
	28	7.3	B
	29	8.0	Le
	30	8.0	C
	30	7.5	Hu
	30	8.3	J
	31	8.5	G
11	2	7.4	B
	2	7.9	Le
	3	8.4	J
	3	8.0	Le
	4	8.0	Le
	6	7.4	B

222439
S Lacertae

10	30	12.9	Y

223841
R Lacertae

Mo.	Day	Est.	Obs.
10	14	12.5	Y
	30	12.4	Y

230110
R Pegasi

10	12	8.2	O
	15	8.0	O
	18	8.3	Y
	21	8.1	G
	27	7.7	O
	30	7.8	Y
	31	7.9	G
11	2	7.6	O
	3	7.6	Hu
	6	7.6	O

230759
V Cassiopeiae

10	7	8.5	V
	10	8.7	G
	13	8.8	F

V Cassiopeiae

Mo.	Day	Est.	Obs.
10	13	9.0	V
	14	9.2	O
	14	9.3	J
	17	9.4	J
	18	9.3	O
	18	8.8	G
	19	9.7	F
	19	9.5	J
	20	9.3	G
	26	10.1	J
	27	9.3	F
	29	9.9	G
	31	10.1	J
	31	10.2	J
11	3	10.4	J
	3	10.3	V

231425
W Pegasi

10	7	8.6	V
	13	8.5	V
11	2	10.0	V

233335
ST Androm.

Mo.	Day	Est.	Obs.
10	3	9.3	G
	13	9.4	G
	14	9.1	O
	14	8.5	Hu
	16	9.4	G
	17	9.3	G
	24	9.2	G
	29	9.1	G
11	6	9.1	O

233815
R Aquarii

10	3	9.1	G
	7	9.0	G
	30	9.2	G

235350
R Cassiopeiae

10	7	10.2	V
	8	10.0	C

R Cassiopeiae

Mo.	Day	Est.	Obs.
10	10	10.3	C
	11	10.5	L
	13	10 1	V
	14	10.2	B
	14	10.2	L
	15	10.3	L

235939
SV Androm.

10	14	11.9	Y
	30	11.8	Y

Nova Gemin.

10	11	7.7	L
	12	7.8	G
	15	7.9	L
	17	7.8	C
	18	8.1	G
	19	8.1	G
	21	8.0	G
	22	8.7	Bu
	29	8.5	Bu

Total number of observations 1035
" " " stars observed 107
" " " observers 14

Dr. Gray's observations of 202946 SZ Cygni are noteworthy. His record indicates a range of 1.5 magnitudes in a period of 15 days.

Owing to the increase in the size of the monthly reports the secretary has discontinued sending out the advance sheets of observations. He will be very glad however to forward special sets that may be desired at any time.

Observers of 183116 W Lyrae stood a good chance of discovering Borrelly's comet, as it was discovered Nov. 2 in R.A. $17^h\ 47^m$ Dec. $+ 38°\ 57'$. It is good practice to sweep about a bit when observing the variable fields to increase the chances of discovering a comet.

Mr. Leonard and Mr. Burbeck, our new members, are to be congratulated on the good start they have made, sending in this month 47 and 55 observations respectively.

Now that our organization is pretty well perfected, and the members are becoming familiar with the fields, it will be wise to turn our attention to some of the neglected variables. At present we are covering certain stars very well and ignoring others. In time we hope to systematize the work so that the variables that are seldom observed now will be added to our lists. Professor Pickering will, I feel sure, be glad to indicate the variables that should receive more attention. In this way we can greatly increase the value of the service we are rendering.

William Tyler Olcott.
Corresponding Sec'y.

Norwich, Conn.
Nov. 10, 1912.

GENERAL NOTES.

Our next number will appear in an entirely new dress of type, which we hope will be pleasing to our readers. On account of the extra work involved in the change of type the January number may be issued a few days late.

See our advertising pages concerning the "Big Ben" Binder and our special offer to new subscribers. We have often received inquiries from subscribers as to whether we could bind their volumes of POPULAR ASTRONOMY. We do not do binding but the "Big Ben" Binder will enable you to do your own binding, at least temporarily, until the end of the year, when the volume can be put in permanent binding.

Professor O. C. Wendell, of Harvard College Observatory, died very suddenly on November 5. He had charge of the 15-inch telescope, engaged in photometric work, for over twenty-five years. A review of his life work will be given in our next number.

Dr. Sigmund Riefler the inventor of Riefler clocks died at Munich in the latter part of October 1912.

Mr. M. F. Smith has been appointed assistant astronomer at the Yale University Observatory

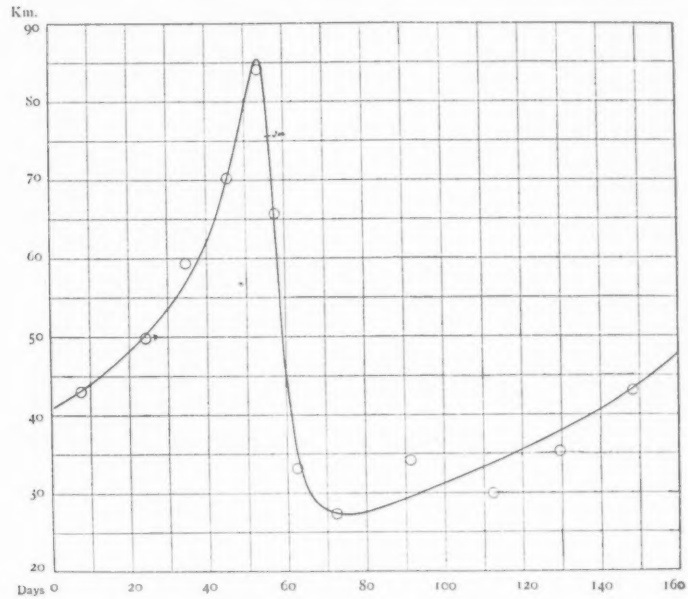
Rev. Jose Algue, director of the Manila Observatory, P. I., is now in this country and is making his headquarters at Georgetown University, of whose observatory he was formerly director. (*Science*, Nov. 1.)

Col. E. E. Marwick, C. B., has been elected president of the British Astronomical Association.

An International Conference on Time Reckoning was opened at the Paris Observatory on October 15 by M. Guist'hau, minister of education; and M. Bigourdan, member of the Institute and of the Bureau des Longitudes, was elected president. The conference was summoned mainly with the object of dealing with various practical uses of wireless telegraphy in the synchronization of time signals throughout the world. (*Science* Nov. 8. 1912.)

New Method of Determining the Angular Diameters of Stars. In the *Astrophysical Journal* for September 1912 Mr. S. Pokrowsky of St. Petersburg gives a new method of determining the angular diameters of stars by means of the elliptic polarization of light. The apparatus is extremely sensitive to atmospheric conditions as well as to starlight and so can yield positive results only at mountain observatories. It is estimated that in the case of Sirius the minimum value of angular diameter that could be detected by this method is 0″.0017.

The Spectroscopic Binary θ^2 Tauri.—In the *Journal of the Royal Astronomical Society of Canada* Professor J. S. Plaskett gives a determination of the elements of the orbit of the spectroscopic binary θ^2 Tauri, from measures



VELOCITY CURVE OF θ^2 TAURI.

of radial velocity at the Lick Observatory in 1903-1908, Yerkes Observatory 1906-1908 and at the Ottawa Observatory 1909-1912. The following are the final elements:

Period	140.50	days
e	0.694	
K	29.128	kilometers
ω	48° 573	
T	2418856.124	Julian Day
γ	42 90	kilometers
Maximum Velocity	+ 85.40	"
Minimum Velocity	+ 27.14	"
$a \sin i$	40,497,000	"

The accompanying diagram shows the velocity curve of the binary during one period.

The Opening of the Mitchel Building of the Cincinnati Observatory was celebrated on Tuesday, October 29. In this building is mounted the original Mitchel telescope of eleven inches aperture, which was purchased by the Cincinnati Astronomical Society of Merz and Mahler, the famous Munich optical firm, seventy years ago. This instrument was first placed in the old Cincinnati Observatory on Mt. Adams, an elevation near the

heart of the city. In 1873 it was removed to Mt. Lookout, and when in 1903 the sixteen inch Clark refractor was purchased, a smaller dome was built for the Mitchel glass. Lately this building has been enlarged by the addition of a lecture room capable of seating about one hundred people, a library and another smaller dome.

The exercises were held in the lecture room of the new observatory. Director Jermain G. Porter in his opening remarks referred to the reputation which Cincinnati has acquired of starting new and untried enterprises, citing as examples the construction of the southern railroad by the city, the establishment of a municipal university, of the coöperative course in engineering and of the night university. Mitchel in procuring for the people of Cincinnati, at that time a frontier western city, a telescope rivaling the great Pulkova glass, then the largest in the world, justly ranks as the originator of this progressivism. For though the observatory was not at first a municipal institution, it was nevertheless erected by and for the people; and the new Mitchel Building, designed chiefly for the accomodation of the public, worthily carries out the idea of the illustrious founder of the observatory.

Mr. Alfred K. Nippert, chairman of the Observatory Committee of the University Board, and Mr. William H. Anderson, a former chairman, spoke in a most interesting manner of the history of the founding of this new building and of the advantages which accrue to the city from maintaining a municipal university and observatory.

The addresses of Dr. Everett Yowell on the debt which astronomy owes to Mitchel, and of Dr. Elliot Smith on the scientific work of the observatory, it is hoped will be published in an early number of POPULAR ASTRONOMY.

Finding out the Nature of the Stars.—Auguste Comte, the great French positivist, predicted that humanity must limit itself to knowledge of the solar system, and the sidereal regions would be forever beyond its intellectual powers.

The invention of the spectroscope and its application to Astronomy has shown the futility of prophesying limitations. Today through it we know the chemistry and physical conditions of the stars, better than we know that of the interior of the Earth.

In May, 1885, Professor Pickering began the use of the objective prism to photograph the spectra of the stars.

As the name implies, the instrument consists of a large prism, placed in front of a photographic telescope, by which a photograph of the spectra of the stars, and not of the stars themselves, is obtained. This method has some limitations but it has two great excellences,—first, by it the spectra of many stars can be obtained simultaneously, and second, because of the usual short dispersion and small loss of light, images of the spectra of very faint stars are obtained; thus giving, with a minimum of labor, material from which much information as to the spectral type of even the faint stars may be acquired. The simplicity of the method in no way limits its accuracy.

The astronomers who use the largest refractors, with slit spectroscopes attached, all testify to the accuracy of the classification based upon plates taken with an astronomical doublet and an objective prism. The results of the use of the objective prism spectroscope are found in the great number of spectrum plates, estimated at forty thousand, which now exist in the photographic library at Harvard. From this material Mrs. Williamina P. Fleming

discovered many new variable stars, identified as such by their characteristic bright line spectra. A catalogue of stars having peculiar spectra has been recently published in the Harvard Annals. But, most valuable of all, these plates have been used as a basis for the Draper Memorial Catalogue, which gives the spectra of the brighter stars of the sky following a notation originated at the Observatory, and called the Draper Classification.

In the beginning this classification was empirical, based entirely upon apparent differences in the light of the stars, and for all the observers knew not representative of any specially significant differences in the stars themselves, but as the years have passed, and wider knowledge has been brought to the problem, it has become more and more evident that the classification is in fact based upon physical differences in the stars, that, in reality, separate them into families. (From the Report of the Committee to Visit the Astronomical Observatory of Harvard College.)

The Draper Classification of Spectra.—Among the astronomical events of recent years, none are more gratifying to the friends of the observatory than the almost universal acceptance of the Draper Classification. In connection with the International Solar Union held at Mount Wilson in September, 1910, where the largest and most representative gathering of the Astronomers of the world took place, it was voted unanimously to extend the scope of the Union to include general Astrophysics, and among its first acts the appointment of a Committee on the Classification of Stellar Spectra. This Committee opened correspondence with the Astrophysicists of the World, and the results of their investigation are given in the Astrophysical Journal of April, 1911

The replies are quite extensive and in detail, and therefore cannot be given here. Enough for our purpose to mention that the significant and gratifying result was brought out, that not only did almost all the Astronomers approve of the Draper Classification, but that it was in practical use generally, so that any future improvement must grow out of and be based upon that Classification.

Another significant event in this connection took place at the recent International Conference of the Superintendents of the Nautical Almanacs of the World, when they adopted the following resolution:—

"The Conference decides that the names of stars shall be accompanied by a letter indicating their spectral type, in terms of Pickering's notation. It is of the opinion that these indications (so far as they have been determined) shall in the future be given to the list of 3064 stars to be published by the Bureau des Longitudes."

The wide interest of the astronomical world in this subject is shown by the multitude of calls made upon the Observatory for information in regard to the classification of particular stars.

The photographic library gives the basis from which the expert knowledge of the Observatory can furnish the information desired. During the past year more than 400 stars have been classified at the solicitation of some of the principal observatories of the United States, England, France, Italy, and Germany.

The Revised Draper Catalogue of which we have spoken will require from four to five years to complete, and when finished will fill four or more volumes of the Annals. (From the Report of the Committee to visit the Astronomical Observatory of Harvard College.)

The Work of a Woman Astronomer.—In this connection it is a pleasure for the committee to speak of the admirable work of Miss Annie J. Cannon. At the present time she is the one person in the world who can do this work quickly and accurately. Through familiarity with it she has acquired such a perfect mental picture not only of the general types, but of their minute subdivisions, that she is able to classify the stars from a spectrum plate instantly upon inspection without any comparison with photographs of the typical stars. This gives her great speed in classification amounting to no less than 300 stars an hour. Certainly a wonderful performance. The amount of work therefore which she is able to accomplish in stellar classification is limited only by the number of helpers at her disposal to do the less expert work of identification and reduction. At the same time her great speed in no way limits the accuracy of her estimates. From an investigation of her probable error based upon parts of the sky where she has made independent duplicate estimates, it is found that her average deviation amounts to only one tenth of a unit.

Miss Cannon by virtue of her unique skill in this branch of science is doing so much for Modern Astronomy and bringing such credit to the Observatory that she deserves official recognition which she has not received. It is an anomaly that, though she is recognized the world over as the greatest living expert in this line of investigation, and her services to the Observatory are so important, yet she holds no official position in the University. At present as her appointment is by the Observatory, and not by the University, her name does not appear in the Catalogue or other official publications of the University. It is the unanimous opinion of the Visiting Committee that the University would be honoring itself and doing a simple act of justice to confer upon her an official position which would be a recognition of her scientific attainments. (From the Report of the Committee to visit the Astronomical Observatory of Harvard College.)

The Spectra of Double Stars.—In *Annals* of Harvard College Observatory, Vol. 56, No. 7. Miss Annie J. Cannon publishes a catalog of the spectra of 745 double stars obtained from photographs taken with objective prisms. It is of interest to note how these double stars are distributed among the different spectral classes. In the following table are given the distribution in spectral classes (1) of stars brighter than magnitude 6.25, as tabulated in Lick Observatory Bulletin, No. 196; (2), of all the double stars in the catalog under consideration; (3) of those double stars in which the spectra of both components are catalogued.

	Stars > 6.25 per cent		Double Stars per cent		Sep. Comp. per cent	
B	11.7		15.1		13.8	
A	30.9	54.4	36.6	73.4	37.4	67.4
F	11.8		21.7		16.2	
G	10.0		13.0		15.6	
K	28.1	45.6	11.8	25.7	15.8	32.6
M	7.5		0.9		1.2	
Misc.			0.9			

There is, as we should expect, a much larger proportion of double stars among the earlier spectral classes than of single stars as tabulated in the first column. This may be due to two causes both arising from the greater effective

stellar age of stars in the later spectral classes. In a large proportion of these systems the components may have separated so far that they are no longer recognized as a double star system; or the effective age of the system may be so great that the smaller component has become non-luminous and for this reason the binary character of the system is yet unknown. If we tabulate only those systems in which the spectra of both components are catalogued we restrict ourselves to stars of separation in most cases as great as 10″, that is, to stars whose effective age is relatively great. Thus we should expect a somewhat larger proportion of later class stars than we find when we consider all the systems.

If we consider the relation in spectral class of the two components of the 246 systems in which both spectra are catalogued we find:

108 systems	with components of the same spectral class	54.1	per cent
48 "	" " differing <1 " "	19.6	"
19 "	" " " 1 " "	7.8	"
175 "	" " of nearly the same " "	71.5	"
66 "	" " differing >1 " "	26.5	"
5 "	, brighter component, composite spectrum	2.0	"

It is clear from this tabulation that in nearly three-fourths of the systems considered the spectra of the two components are of nearly the same class. In the 66 systems the components of which have different class spectra the fainter component has a later class spectrum than the primary in just about one-half. It must be noted here, however, that there is not a great deal of difference in the magnitudes of the components in these systems. In a large number of systems with components of widely differing magnitudes, the above conclusion might not be evidenced at all. In the five systems, in which the spectrum of the brighter component is composite, that of the companion is early class, B_3 B_8, B_9, A, A_2.

Of the 175 systems with components of nearly the same spectral class, 26 per cent have components differing more than one magnitude in brightness. Of the 66 systems with components of different spectral classes 50 per cent have components differing more than one magnitude. In all the five systems, the brighter components of which have composite spectra, the companion is at least one magnitude fainter than the primary The indications are, then, that where the components of a double star system differ considerably in magnitude there is greater liability of divergence in the character of their spectra. If we consider the systems in which both components are of early or both of late spectral class we find in either case 25 per cent of the systems have components differing more than one magnitude. There seems to be no greater probability of difference in the magnitudes of the two components in either class.

It is to be hoped that there may be devised soon some means of obtaining the separate spectra of the components of comparatively close double star systems and of those systems in which there is a large difference in magnitude between the primary and secondary. Data of this nature would aid greatly in the study of the evolution of double star systems.

RALPH E. WILSON.

Lick Observatory, Oct. 26, 1912.

The Spectroscopic Binary β Scorpionis.—In the *Lowell Observatory Bulletin* No. 54 Mr. J. C. Duncan gives a very interesting discussion of the measures of radial velocity of the spectroscopic binary β Scorpionis. "The variability of the radial velocity of the brighter visual component of β Scorpionis was first announced by Dr. Slipher in 1903, from observations with a three prism spectrograph. In 1908, upon obtaining some single prism plates of this star, he found that the H and K lines of calcium were faint and sharply defined instead of broad, diffuse and conspicuous, as in the spectrum of the sun and of many other stars; also, that these lines seemed not to share in the oscillation of the other lines of the spectrum—an appearance and behavior similar to that first noticed by Hartmann in δ Orionis in 1904. The explanation suggested by Hartmann was that a mass of calcium vapor was moving with uniform speed between the star and the earth, and producing the calcium lines by selective absorption of the star's light, the star itself containing no calcium. This view is supported by Slipher's observations of other stars in the Scorpio, Orion and Perseus regions, which show that faint, sharp calcium lines characterize the spectra of many stars in those parts of the sky—as if the cloud extended in front of these stars also."

From the measures of three helium lines and two hydrogen lines on 90 spectrograms, taken between 1908 July 2 and 1912 July 7, Mr. Duncan obtains the following elements:

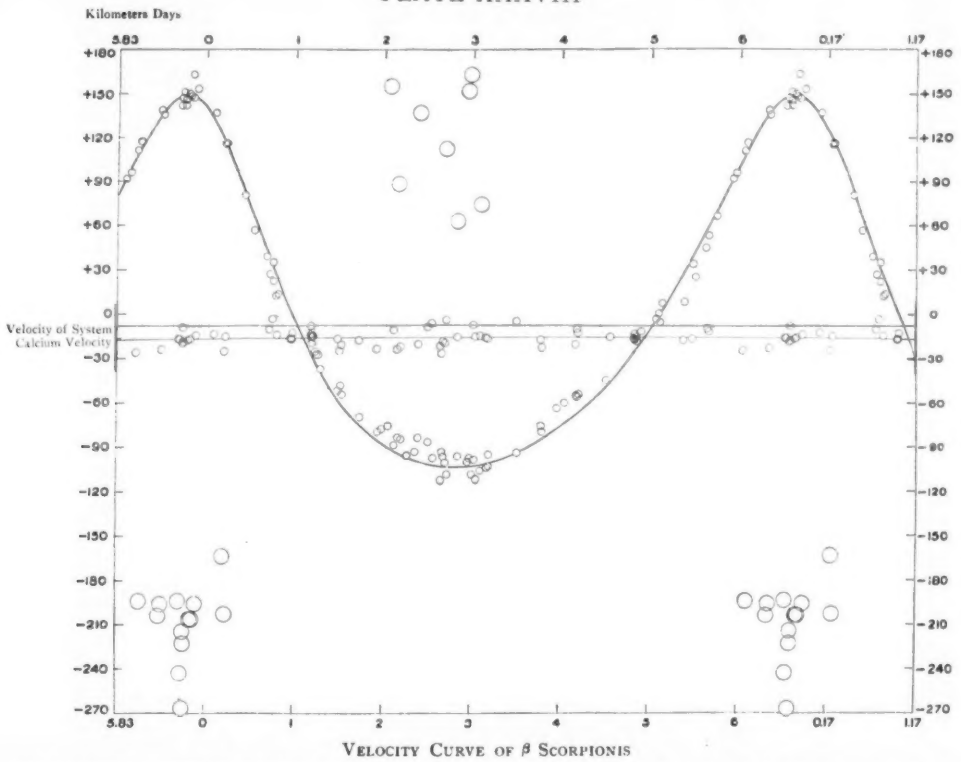
Period	$P =$	$6^d.8284$	
Mean daily motion	$\mu =$	$52°.721$	
Eccentricity	$e =$	0 .27	
Greenwich mean time of periastron	$T =$	1908 July 3.000	
	$=$	J. D 2418126.000	
Velocity of center of mass of system	$V =$	$-$ 8.0 km. per second	
Ratio of masses	$=$	0.75	
		Bright comp.	Faint comp.
Distance node to periastron	$\omega =$	20°	200°
Semi-amplitude of velocity curve	$K =$	126 km.	166 km
Maximum velocity	$=$	+ 148	+ 119
Minimum velocity	$=$	$-$ 104	$-$ 211
	$m \sin^3 i =$	9.0	6.8
Projected semi-axis major	$a \sin i =$	10990000 km.	14450000 km.
Probable error of observation of weight unity			± 5.7 km.

There is thus indicated the phenomenon of two immense suns, with dense envelopes of hydrogen and helium, with their centers about twenty diameters of the sun apart, whirling around each other every seven days, one with a velocity of 126 kilometers, the other of 166 kilometers per second, and moving toward the sun at the rate of 8 kilometers per second.

At the same time, the calcium lines of the same star indicate no periodic shift, but yield a practically constant radial velocity, toward the sun, of 16.6 kilometers per second. This may mean, as suggested above, that there is a vast cloud of calcium surrounding the star or between us and it, which does not partake of the whirling motion of the pair. As Mr. Duncan points out, the difference of eight kilometers in radial velocity between the binary system and the source of calcium absorption tends to support the view that the calcium lines have their origin in something independent of the binary pair.

The present writer would point out that the component of the solar velocity in the direction of β Scorpionis is about 10 kilometers, so that the radial velocity of the binary system is practically accounted for by the motion of the sun, and therefore the star is nearly at rest (radially to us) in space, while the calcium cloud, if there be such, is moving toward us at the rate of 6 or 7 kilometers per second.

PLATE XXXVIII



VELOCITY CURVE OF β SCORPIONIS

The small black circles represent the velocity of the principal component, the large black circles that of the secondary component and the red circles the velocity obtained from the calcium lines.

Orbit of the Visual and Spectroscopic Binary Star ε Hydræ AB.—In the October number of the *Publications of the Astronomical Society of the Pacific* Professor R. G. Aitken discusses the orbit of the binary star ε *Hydræ* AB. This is a visual pair with a period of 15.3 years, and spectroscopic observations in recent years yield both the maximum and minimum radial velocities of the components, so that it is possible to determine certain of the elements of the orbit by both the micrometric and the spectrographic observations, and also to determine the actual dimensions of the orbit. The elements are as follows:

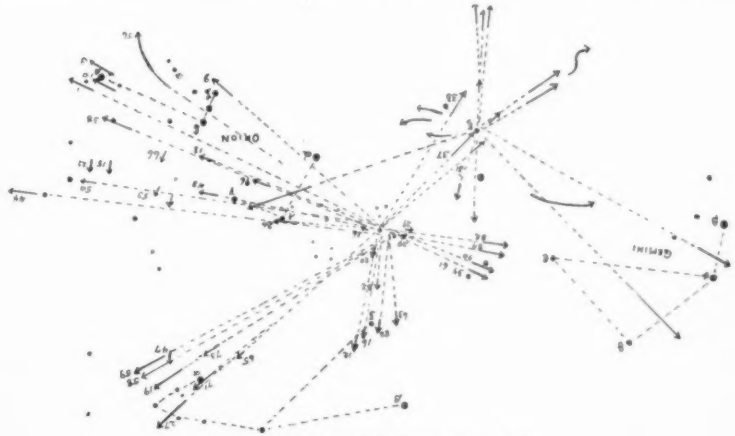
Visual Orbit	Spectrographic Orbit
$P =$ 15 3 years	$P =$ 5588 days
$T =$ 1900.97	$T =$ J. D. 2415375
$e =$ 0.65	$e =$ 0.65
$\omega =$ 270°.0	$\omega =$ 90°.0
$i =$ +49 .95	$V =$ +36.79 kilometers
$\Omega =$ 104 .4	$K =$ 8.45
$a =$ 0″.23	$a \sin i =$ 493,000,000 km.

Angles increasing.

Assuming the ratio of masses of the components to be 0.9, the distance between them comes out 1,359,000,000 kilometers, the parallax of the system 0″.025 and its mass 3.33 times that of the sun, the masses of the two components being 1.75 and 1.58 respectively.

"Within the next five years the companion will again pass through both nodes and also through the periastron point, hence the radial velocity of the primary will reach both maximum and minimum values. Spectrographic observations are greatly to be desired during this interval, particularly as micrometer measures are impossible at the time of periastron. By 1917 the data should be available for a definitive discussion of the orbit."

The Orionids—October 20, 1912.—October 19 was clear with a high wind. The sky was watched from 12:00 until 1:00 a. m. without result. October 20 was clear, with some Cirrus clouds from the west. From 1:45 a.m.



THE ORIONIDS OCTOBER 20, 1912.

till 5:18 101 Orionids, 74 Geminids, 4 Leonids, 2 Canis Majorids and 2 Aurigids were seen. The Orionids were very faint as a rule, and slow, the Geminids bright, very swift; many had curved paths, from a sharp semi-circle to a zig-zag. Fifteen Orionids left trails of white and green (3 green, 12 white); six were red, two yellow, one blue, and the rest white.

Time	Orionids	Others	Notes	
1:45—2:15 a.m.	14	11	Geminids	
2:15—2:45	9	2	1 "	1 Aurigid
2:45—3:15	14	13	12 "	1 "
3:15—3:45	12	6	4 "	2 Taurids
3:45—4:15	16	22	20 "	2 Leonids
4:15—4:45	9	4	3 "	1 Leonid
4:45—5:18	27	24		1 "
$1^h\ 33^m$	101	82		

There were three radiants in Orion, with one nearest ν the most active. The Geminids were more active than the Orionids, but only those that crossed the map were counted. The radiant in Gemini was near ξ Geminorum. The hourly rate was 52 for all, 29 for the Orionids, 23 for the Geminids.

By magnitudes the Orionids were as follows;

Mag.	0	1	2	3	4	5	6	
No.	4	13	9	28	10	12	25	Total 101

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Descriptive Astronomy, an elementary exposition of the facts, principles, and theories of astronomical science, by Forest Ray Moulton. Publishers American School of Correspondence, Chicago. Price $1.50.

This is a text book on astronomy but, as its title indicates, deals only with descriptive astronomy. There are no mathematical formulae in it, so that it may be read by anyone who has had only enough of geometry to understand the meaning of illustrative diagrams. The book is written in a clear and interesting style and is profusely illustrated with diagrams and many of the best recent celestial photographs. It will be an excellent textbook for those who wish to read astronomy by themselves, or in correspondence with an instructor, and it may be that college instructors in astronomy will find this the book to use, with students who have no taste for mathematics.

After a few preliminary considerations as to the value and origin of science, the present value and scope of astronomy, the author takes up the subject under the nine general topics: the earth as an astronomical body; the constellations; time; the moon; the solar system, comets and meteors; the sun, the sidereal system; cosmogony or the evolution of worlds. In all parts of the book, so far as we have noted, the statements are accurate and the facts of observation and theory are brought well up to date. The entire book is printed on heavy plate paper so that the illustrations are splendidly printed and the general appearance is very attractive.

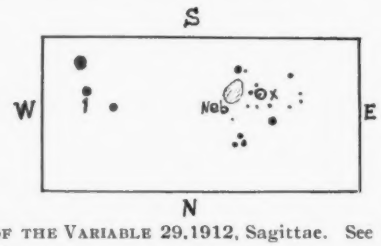

CHART OF THE VARIABLE 29.1912, Sagittae. See page 664.